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From the Editor,

This issue contains the monumental work of J. Huber of the Canadian Forest Service in Ottawa, who spent years reviewing and measuring the tiny Mymarid, *Anaphes* sp., an important group for biological control and systematics. This group is extremely difficult to work with due to its tiny size in spite of the many optical tools available. I am sure you will find that the clarity of the plates of these seldom-seen *Anaphes*, will add a new dimension to your viewing pleasure of insects.

It is not only the tiny *Anaphes* sp. that has gone unnoticed, but much larger Apids and Orthopteroids are showing up as new Canadian records, when collections are examined more closely by dedicated individuals. The continued work of T. Romakova at the Royal Ontario Museum in Toronto, revising the bees of Ontario, reports seven new records of Apids for Canada, while S. Marshall's group of the Systematics Laboratory at the University of Guelph, reports seven records of Orthoptera for Canada and one new record for Ontario.

Dealing with insecticide resistance is a long-standing problem in apple orchards everywhere. D. Pree's group of the Agriculture and Agri-Food Canada laboratory in Vineland presents a profile of the dynamics of insecticide resistance in some Ontario orchards over three years. This study demonstrates how insecticides from different chemical groups interact with one another, and suggests how to reduce insecticide resistance in apple orchards.

Ontario is also known for its wine and it is fitting that JESO presents works on vineyard pests. In 2001, Ontario vineyards became infested with aphids and the multicoloured Asian lady beetle soon followed, which created a new problem for the wine industry. If large populations of the beetle are present in the vineyards when the grapes are harvested, the beetles get crushed along with the grapes, tainting the wine. D. Pree's group developed a protocol to provide an immediate or short-term response to the new problem.

I thank Martin Damus again for his continued service to the Society in providing the cover drawing of the *Anaphes* laying an egg. Thanks to Karen Jamieson and Mark Primavera for the technical layout of this volume. Our associate editors along with reviewers from across Canada and the United States provided valuable feedback to the authors. Finally, we are already working on volume 136 of JESO and we would be pleased to read your work and consider it for publication.

Yves Prévost
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REVIEW OF THE DESCRIBED NEARCTIC SPECIES OF THE *CRASSICORNIS* GROUP OF *ANAPHES S.S.* (Hymenoptera: Mymaridae)

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Abstract *J. ent Soc. Ont.* 135:3-86

The 13 nominal species of the *crassicornis* group of *Anaphes s.s.* (previously known as *Patasson*) in North America are redescribed and keyed. Primary types are illustrated and the biology of several economically important species is summarized. Host-induced morphological variation is a problem in defining the species. Crossing experiments between nominal species reared from various economically important hosts are needed to determine whether similar morphological species are biologically distinct or not, as follows: *Anaphes conotracheli* reared from *Conotrachelus* spp. with *A. pallipes* reared from *Cylindrocopturus adspersus* and *Rhagoletis pomonella*; *A. luna* reared from *Hypera* spp. (especially *H. postica*) with *A. victus* reared from *Listronotus oregonensis* and with *A. sordidatus* reared from *Tyloderma foveolatum*; *A. pullicrurus* reared from *Chaetoctema denticulata* with *A. cotei* reared from *Listronotus oregonensis.* Molecular studies may also help resolve species limits. Hosts are still unknown for *A. brunneus*, *A. confertus*, and *A. longiclava*. *A lectotype* is designated for *A. luna.*

Résumé

Les 13 espèces nominales décrites du groupe *crassicornis* du genre *Anaphes s.s.* (autrefois connu sous le nom de *Patasson*) d'Amérique du nord sont redécrites et une clé d'identification est présentée, tout cela basé sur l'étude des types primaires. Les types primaires sont illustrés et un sommaire de la biologie de diverses espèces d'importance économique est présentée. La variation morphologique causée par l'hôte est un problème pour définir les espèces. Des essais de croissement entre les espèces nominales, élevées de divers hôtes d'importance économique, sont nécessaires pour déterminer si les espèces morphologiquement semblables sont biologiquement différentes ou non. Les croisements devraient être faits comme suit: *Anaphes conotracheli* élevées de *Conotrachelus* spp. avec *A. pallipes* élevées de *Cylindrocopturus adspersus* et *Rhagoletis pomonella*; *A. luna* élevées de *Hypera* spp. (surtout *H. postica*) avec *A. victus* élevées de *Listronotus oregonensis* et avec *A. sordidatus* élevées de *Tyloderma foveolatum*; *A. pullicrurus* élevées *Chaetoctema denticulata* avec *A. cotei* élevées de *Listronotus oregonensis.* Des études moléculaires pourraient aussi aider à résoudre les limites entres espèces. Les hôtes demeurent toujour inconnus pour *A. brunneus*, *A. confertus*, et *A. longiclava*. Un lectotype est désigné pour *A. luna.*

Introduction

Most of the biological literature on Mymaridae involves species of only two genera, *Anaphes* Haliday and *Anagrus* Haliday, because they are important for the biological control of pests of several major crops (Huber 1992, Chiappini *et al.* 1996). About 235 species of *Anaphes* have been described but few have host records associated with them. Chrysomelidae or Curculionidae are the most commonly reported hosts, but some *Anaphes* species have been reared from other families in Coleoptera, Diptera, Hemiptera or Hymenoptera (Symphyta). The several taxonomic treatments of *Anaphes* have resulted in a somewhat complicated nomenclatural history as discussed by Debauche (1948), Annecke and Doutt (1961), Schauff (1984a), and Huber (1992). Huber (1992) divided the genus into two subgenera, *Anaphes* (*Anaphes*) and *Anaphes* (*Yungaburra*), based on differences in male antennae. Males of species of *Anaphes* (*Yungaburra*) have each of the 11 flagellomeres bearing at least one longitudinal sensillum whereas males of *Anaphes s.s.* apparently have only 10 flagellomeres because Fl_1 is extremely reduced and lacks longitudinal sensilla. Huber (1992) subdivided *Anaphes* (*Yungaburra*) into three species groups (the *amplipennis* and *nitens* groups, and an unnamed group) and *Anaphes s.s.* into two species groups, the *fuscipennis* group and the *crassicornis* group, based on the number of claval segments in the female antennae. Species of the *crassicornis* group are separated by their two-segmented clava from species of the *fuscipennis* group, which have a one-segmented (entire) clava. Huber (1992) reviewed the nine described species of the *fuscipennis* group in North America; the described species of the *crassicornis* group in North America are reviewed here. Species in the latter group have previously been classified either in their own genus, *Patasson* (e.g. Kryger 1934), or as a subgenus of *Anaphes* (e.g. Debauche 1948). In the Nearctic region, the *crassicornis* group includes 13 nominal species: nine catalogued under *Patasson* by Burks (1979), *A. pallipes* (Ashmead) catalogued under *Anaphes* by Burks (1979) and transferred to the *crassicornis* group by Huber (1992), and three additional species described by Huber in Huber *et al.* (1997). Eight of the species [*A. calendrae* (Gahan), *A. conotracheli* Girault, *A. cotei* Huber, A. *diana* (Girault), *A. luna* (Girault), *A. listronoti* Huber, *A. pullicrurus* Girault, and *A. victus* Huber] have been reared from economically important pests. *Anaphes luna* was imported from Europe for biological control and released in Utah where it successfully established and spread. *Anaphes diana* was also imported from Europe and was released in Delaware, Idaho and Kentucky but field establishment is uncertain (Yeargan 1985). The remaining four species [*A. brunneus* (Doutt), *A. gerissophaga* (Doutt), *A. longiclava* (Doutt), and *A. confertus* (Doutt)] are known from only one or a few specimens, either reared from hosts of no economic importance or not reared and without known hosts. Despite their economic importance and abundance, the taxonomy of *crassicornis*-group species is difficult and most of the species cannot easily be identified.

As a first step to try to resolve the problem of species identifications, the described species occuring in the Nearctic region are keyed and redescribed, and their type specimens are illustrated. The total number of *Anaphes* species occuring in America north of Mexico can only be guessed at. Only three collections (CNCI, UCRC, USNM, acronyms explained below) have considerable numbers of *Anaphes* specimens (several thousand individuals in total) and most would have to be slide mounted for detailed studied before a reasonable estimate could be made. Based on my current knowledge of the genus I think the number of North American morphospecies is perhaps around two or three times the number already described, i.e. 40-50 species in total, more or less divided equally between the two species groups. Comparison with

other zoogeographical regions is not helpful for determining the size of the North American fauna because none of their faunas (except Europe) have been studied systematically. The European situation presents a major problem because of the typological species concept used by the single author who described most of the approximately 160 nominal species from relatively few localities. Most of his species are likely synonyms of one another.

Materials and Methods

Morphological terms used and measurements, given in micrometers (µm), are as described in Huber (1992) and Gibson (1997). All the features mentioned in the species diagnoses must be taken into account when comparing a specimen; if only some features match and others do not it is likely that the specimen does not belong to the species in question. Descriptions include the mean and, in parentheses, the range and number of specimens measured. Primary types were measured separately (Table I). Their measurements are not included in the species statistics, thus permitting independent comparison with non-type material. Where possible, qualitative features were used to identify species, but there seem to be few such features in species of *Anaphes* so considerable reliance was placed on measurements and ratios. The relative length of tarsomere 1 to 2 has not been used before. Using slide-mounted specimens, each tarsomere is measured from its base to the proximal point of insertion of the next tarsomere (Fig. 34). The apical tarsomere is measured to the point of insertion of the pretarsus. The pretarsus is not included in total tarsal length. The 'ovipositor length' (Fig. 41) was measured from the basal loop to the apex of the sheaths instead of to the apex of the ovipositor itself because the ovipositor apex is not always clearly visible when it is hidden by the sheaths. The true ovipositor length is acutally slightly less than the length measured from the apex of the sheaths. For measurements to be exact, structures being measured must have both end-points in focus at the same time. This was not the case for some measurements because of the poor quality of most of the slide-mounted specimens available for study. Thus a certain amount of unavoidable inaccuracy occurs that increases the range for a given structure. In particular, absolute body measurements taken from slide-mounted specimens are somewhat inaccurate because the specimens usually had the head collapsed or mounted obliquely. Approximate head length was added to the separate measurements of mesosoma and metasoma to obtain total body length. Because most specimens, either representing different species or the same species reared from different hosts, were mounted in the same way, comparison of measurement among specimens shows the relative changes in size reasonably well.

Because of small sample sizes (less than 30) the sample standard deviation, which is slightly larger than the standard deviation, was calculated. Species limits based on ranges and deviations are thus somewhat broadened and greater overlap among the measurements of different species occurs. Until many more, well prepared slide-mounted specimens of each species become available for measurement the limits of variation cannot be defined more accurately.

Photographs of wings and antennae were made with a digital camera attached to a compound microscope. The species of the *crassicornis* group are so similar that long descriptions are simply repetitious. The descriptions consist mainly of measurements and, together with the diagnoses, should suffice to recognize a particular species. Abbreviations used are: Fl_1-Fl_6 = funicle segment 1 to 6, FWL/FWW = forewing length/forewing width, LMC = longest marginal cilia of forewing or hind wing.

Specimens were borrowed from the following institutions.
CASC - California Academy of Science, San Francisco. W. Pulawski.
EMEC - Essig Museum of Entomology, University of California, Berkeley. R. Zuparko.
CNCI - Canadian National Collection of Insects, Ottawa. J. Huber.
INHS - Illinois Natural History Survey, Urbana. K.C. McGiffin.
UCRC - University of California, Riverside. S. Triapitsyn.
USNM - National Museum of Natural History, Washington, DC. M.E. Schauff.

Variability in *Anaphes* species

Females are the most commonly collected sex and the only known sex for some species. Therefore, mymarid taxonomy is based almost exclusively on females, and only females can be identified fairly reliably using morphological features alone. Males are usually ignored unless they can be definitely associated with corresponding females. Sexual variation is therefore not a problem to consider in mymarid taxonomy. Another kind of variation occurs when individuals of a gregarious species, e.g. *A. calendrae*, presumably obtain varying amounts of nutrients from the single egg in which they develop, resulting in overall size differences. The source of variation with the greatest influence in modifying morphology appears to be the host. Different host species may cause qualitative as well as quantitative morphological changes in their parasitoids. For example, in *A. iole* Girault not only are specimens reared from smaller hosts smaller in size but loss of longitudinal sensilla on Fl_4 occurs, with a concomitant change it its proportions (Huber and Rajakulendran 1988). Evidence is presented below that two nominal *Anaphes* spp., *A. pallipes* and *A. conotracheli*, reared from *Cylindrocopturus adspersus* LeConte and *Conotrachelus* spp., respectively, may be a single species. The differences between these two putative species are similar to those found for *A. iole* reared from its different hosts. If the length of a structure varies continuously between two extremes (e.g. *A. calendrae*, as described below) depending on host size, this can be more easily taken into account when characterizing the limits of variation in a species than a disjunction in qualitative features. In the later case, one may easily, but incorrectly, propose two or more species (as was probably done by some authors working on the European fauna) unless the biology and host range are known or crossing experiments can be performed to demonstrate conspecificity. Conversely, morphologically almost identical species that are biologically different are known to occur, e.g. *A. sordidatus* Huber and *A. listronoti* Huber (Huber *et al.* 1997). The lack of host information and difficulty of doing crossing experiments with most described *Anaphes* species greatly hinders a proper understanding of species limits in the genus.

Key to females of described Nearctic *crassicornis*-group species of *Anaphes*

1 Back of head with occipital suture short, bent inward and pointing ventromedially towards occipital foramen (diverging strongly away from outer orbit of eye) (Figs. 31, 32); forewing with posterior margin hyaline for most of its length until mid-point of wing apex, with at most only a short brown section along ventral margin towards apex (Figs. 16, 19, 26) 2

- Back of head with occipital suture long, straight, pointing ventrally (not diverging strongly from outer orbit of eye) (Fig. 30); forewing with posterior margin and entire apical margin brown, similar to anterior margin (Figs. 17, 18, 20-25, 27-29) 4

2(1) Fl_2 of antenna at most 3.3 times as long as wide and at most 1.8 times as long as Fl_1; ovipositor at least 1.8 times hind tibial length 3
- Fl_2 of antenna at least 4.4 times as long as wide and at least 2.2 times as long as Fl_1 (Fig. 1); ovipositor at most about 1.6 times hind tibial length ..... *brunneus* (Doutt)
3(2) Fl_4 with 2 longitudinal sensilla ..... *conotracheli* Girault
- Fl_4 at most with 1 but usually without longitudinal sensilla ..... *pallipes* (Ashmead)
4(1) Ovipositor arising posterior to base of gaster(ovipositor/hind tibia ratio at most 0.9) ... 5
- Ovipositor extending at least to base of gaster and often under mesosoma towards head (ovipositor/hind tibia ratio greater than 1.0) 6
5(4) Fl_4 almost quadrate, without longitudinal sensilla (Fig. 3) ..... *confertus* (Doutt)
- Fl_4 at least twice as long as wide, usually with 1 or 2 longitudinal sensilla (Fig. 6) (European species, establishment in North America uncertain) ..... *diana* Girault
6(4) Fl_2 without longitudinal sensilla and somewhat narrower than Fl_3 7
- Fl_2 with 1 or 2 longitudinal sensilla on one or both antenna and about same width as Fl_3 . 12
7(6) Forewing narrow, its length/width ratio greater than 7.3 (Figs. 20, 22, 27) 8
- Forewing broader, its length/width ratio less than 6.5 (Figs. 17, 23-25, 28, 29) 10
8(7) Setae on vertex between ocelli and on thorax conspicuous, long and erect, the four setae between ocelli at least half as long as distance between posterior ocelli, the two on midlobe of mesoscutum extending to posterior margin of mesoscutum (assuming they are laying flat) and the one on each axilla extending past posterior margin of anterior scutellum (Fig. 41) ..... *gerrisophaga* (Doutt)
- Setae on head and thorax shorter and mostly inconspicuous, the four setae between ocelli at most as long as anterior ocellar diameter 9
9(8) Fl_2 long and slender, its length/width ratio at least 4.8, and the remaining segments also relatively long and slender (Fig. 5) ..... *cotei* Huber
- Fl_2 shorter and broader, its length/with ratio at most 3.5, and the remaining segments also relatively shorter and broader (Fig. 13) ..... *pullicrurus* (Girault)
10(7) Hind leg with tarsomere 1 almost 1.5 times as long as tarsomere 2 .... *calendrae* (Gahan)
- Hind leg with tarsomere 1 slightly shorter than tarsomere 2 11
11(10) Forewing length/width ratio at least 5.7; body length 413-603 µm [specimens from original 1911 introduction] ..... *luna* Girault (part)
- Forewing length/width ratio at most 5.4 (4.6 in holotype); body length 413 (holotype; the single paratype not measurable) ..... *longiclava* (Doutt)
12(6) Ovipositor length averaging 434 µm (374-511, n=13) .... *listronoti* Huber, *sordidatus* Huber
[Note: these species cannot be separated morphologically (see Huber *et al.*,1997); *sordidatus* has been reared from *Tyloderma foveolatum* (Say) whereas *listronoti* has been reared from *Listronotus oregonensis* (LeConte)].
- Ovipositor length less than 350 µm for Texan and Michigan populations, and averaging 365 mµ (351-380, n=5) for Quebec population .... *victus* Huber ?and *luna* Girault (part)

***Anaphes brunneus* (Doutt)**
(Figs. 1, 16, 35)

Anaphoidea brunnea Doutt, 1949: 159 (original description).
Patasson brunnea; Burks, 1958: 63 (catalog).
Patasson brunneus; Peck, 1963: 32 (catalog, hosts); Burks, 1979: 1030 (catalog).
Anaphes brunneus; Huber, 1992: 73 (list).

Type material. HOLOTYPE ♀ (EMEC), examined. On slide labelled: 1."by sweeping native vegetation. Forestville, Sonoma Co., Calif. April 16, 1947 R.L. Doutt". 2. "*Anaphoidea brunnea* Doutt ♀ Type" (red label). The holotype is in fairly good condition, with the right pair of wings and right foreleg detached, and with the head detached and positioned laterally and one antenna detached. Measurements are given in Table I. PARATYPES: same data as holotype (2 ♀, USNM, EMEC); Contra Costa Co., El Cerrito, 6.iii.1948, R.L. Doutt (1 ♀, EMEC).

Diagnosis. Occipital suture short, angled inwards towards dorsal margin of occipital foramen (as in Figs. 31, 32); forewing clear on posterior margin to mid-point of wing apex (Fig. 16); Fl_2 at least 4.3 times as long as apical width (Fig. 1).

Anaphes brunneus, A. pallipes, A. conotracheli and the Palearctic *A. pectoralis* are all closely related based on the short, angled occipital suture and the clear hind margin of the forewing. They also share these two features with *A. iole* of the *fuscipennis* species group. *Anaphes brunneus* differs from *A. pallipes* and *A. conotracheli* by its longer Fl_2, the longest funicle segment. Except for the antennal and ovipositor proportions, specimens of *A. brunneus* and those of *A. conotracheli* appear to be identical so the species may be synonymous. More, preferably reared, specimens from hosts in western North America are required so variation can be assessed adequately to determine if the species are really the same.

Description. Female. *Colour* (from uncleared type slides). Dark brown with antennae and legs beyond coxae lighter. Forewing (Fig. 16) with posterior margin hyaline almost to apex of wing.

Body length. 484 (428-535, n=4, from slide-mounted types). Body length is approximate because the specimens cannot be measured accurately due to breakage and poor orientation.

Head. Width 170 (n=1). Occipital suture short, angled inwards towards dorsal margin of occipital foramen (as in Figs. 31, 32). Ocellar setae as long as about half diameter of anterior ocellus.

Antenna. Scape with ventral margin almost straight, with faint, oblique striations on inner surface. Fl_5 and Fl_6 each with 2 longitudinal sensilla (Fig. 1). Fl_1 with base about two-thirds width of apex. Fl_3 with 1 (holotype) or 2 (paratypes) longitudinal sensilla. Fl_4 without longitudinal sensilla in holotype and one paratype, and with1 longitudinal sensillum in remaining two paratypes. Measurement of antennal segments are given in Table II.

Mesosoma. Pronotum and mesonotum with short, inconspicuous setae.

Wings. Forewing length 671 (626-721, n=3), width 146 (132-160), FWL/FWW 4.7 (4.55-4.75), LMC 145 (140-150), their length about equal to forewing width; marginal space 90 (84-97), medial space triangular, cubital line of setae closest to posterior margin near the retinacular seta and further away distally, with a distinct gap of about one setal length between the cubital line and posterior margin of wing. Hind wing length 649 (610-705, n=3), width 29 (n=1), with 5-10 microtrichia medially on blade in apical half, LMC 117 (103-131, n=3).

Legs. Foretibia with 8-10 sensilla chaetica. Hind tarsomere 1 slightly shorter than tarsomere 2 (Table I).

Metasoma. Ovipositor length 342 (n=1), 1.62 times length of hind tibia, extending under mesosoma at least to level of base of mesocoxa and usually to base of forecoxa. Gaster with rather blunt apex (Fig. 35).

Male. Unknown.

Distribution. USA (CA).

Material examined. Only the four specimens of the type series were examined. One specimen from TX, Jim Wells Co., La Copita Res. Station, north fence pasture S2, 23.iii.1990, G. Zolnerowich (1♀ on card, CNCI) may be this species but more material is needed from this locality for slide mounting to be certain.

Hosts and Biology. Unknown.

Anaphes calendrae (Gahan)

(Figs. 2, 17, 33, 36)

Anaphoidea calendrae Gahan, 1927: 32 (original description); Marlatt, 1929: 11 (shipment to Hawaii); Satterthwait, 1931: 171 (hosts, life cycle, biology); Williams, 1929a: 227 (release in Hawaii); Williams, 1929b: 29 (introduction into Hawaii); Williams, 1931: 216 (release in Hawaii); Clausen, 1940: 101 (host mention); Doutt, 1949: 160 (key); Vaurie, 1951: 39 (host list); Thompson, 1958: 569 (host list).

Patasson calendrae; Peck, 1951: 414 (catalog, hosts); Peck, 1963: 32 (catalog, hosts); Beardsley, 1964: 340 (insectary rearing); Bianchi, 1964: 346 (release in Hawaii, laboratory hosts); Davis and Krauss, 1964: 395 (release in Hawaii); Davis, 1968: 16 (release in Hawaii); Funasaki, 1969: 285 (release in Hawaii); Davis and Chong 1969: 320 (release in Hawaii); Anonymous 1970: 34 (propagation in Hawaii); Burks, 1979: 1030 (catalog); Collins and Grafius, 1983: 1 (hosts); Clausen, 1978: 274 (importation and release in USA, failed establishment in Hawaii); Huber, 1986: 198 (mention of failed establishment in Hawaii).

Patasson calandrae; Tooke, 1955: 112 (incorrect subsequent spelling).

Anaphes calendrae; Annecke and Doutt, 1961: 49 (key); Huber, 1992: 73 (list); Beardsley and Huber, 2000: 10 (Hawaiian records).

Anaphes (*Patasson*) *calendrae*; Beardsley, 2000: 209 (establishment and probable hosts in Hawaii).

Type material. HOLOTYPE ♀ (USNM), examined. On slide labelled: 1."*Anaphoidea calendrae* Gahan Type & allotype Type No. 29454 U.S.N.M. [red label]". 2." Webst. Gr. # 24117 Progeny of # 24106 bred through eggs of *Calendra destructor*. Kirkwood, Mo. A.F Satterthwait". The holotype is in good condition, uncleared and mounted laterally with the head partially in face view. Its measurements are given in Table I. Three female and one male paratypes are on the same slide as the holotype, which is circled in black. PARATYPES. I examined 38 of the 40 slides and 11 of the 12 original point-mounted specimens listed by Gahan (1927). The specimen(s) from Borschertown, Missouri, were not found. One card-mounted specimen was cleared and mounted in Canada balsam. All paratypes have the same type number as the holotype slide.

Diagnosis. Hind tarsomere 1 distinctly longer than tarsomere 2 (Fig. 33); ovipositor/hind tibia ratio at least 2.1, with the ovipositor extending under mesosoma to apex of forecoxa (Fig. 36).

Description. Female. Colour. Body dark brown. Legs brown except for yellowish base and apex of femora, entire tibiae and basal three tarsomeres. Antenna brown, with scape and pedicel sometimes yellowish. Forewing (Fig. 17) margined with brown along both margins but paler along posterior margin, and with a uniform brown suffusion on blade except for clear longitudinal streak in medial space.

Body length. 467-941µm (n=31, from slide-mounted specimens). Individual size varies considerably depending on host size, as follows (smallest to largest): mean = 538 (467-555, n=5) ex. *S. minimus*; mean = 583 (480-804, n=6) ex. *Sphenophorus parvulus*; mean = 659 (595-757, n=7) ex. *S. pertinax*; mean = 704 (623-749, n=5) ex. *S. costipennis*; mean = 788 (764-808, n=5) ex. *S. callosus*; mean = 896 (857-941, n=3) ex. *S. maidis*.

Head. Width 195-329 (n=18) (see Table XII for measurments from different host species). Occipital suture straight (as in Fig. 30).

Antenna. Inner surface of scape with very faint, slightly oblique reticulations. Fl_3-Fl_6 each with 2 longitudinal sensilla (Fig. 2). Base of Fl_1 distinctly narrower than apex. Length of antennal segments (greatest range, across specimens reared from all hosts): scape 91-158, pedicel 38-67, Fl_1-Fl_6 16-36, 32-96, 34-102, 37-87, 37-80, 37-74, clava 84-126 (see Tables III-IX for measurements from different host species).

Mesosoma. Pronotum and mesonotum with short setae.

Wings. Forewing length 436-882, width 60-141, FWL/FWW 6.26-7.83, LMC 104-146 and 1.1-1.6 times as long as wing width (depending on host from which specimens were reared), microtrichia of blade relatively long, with the apex of one distinctly overlapping base of the next; marginal space 84-169 (extremely variable, depending on host from which specimens were reared); medial space relatively long and narrow, somewhat rectangular; cubital line of setae uniformly separated by about a setal length from posterior margin of wing. Hind wing (Fig. 17) with 0-6 microtrichia medially on blade in apical half (see Tables X and XI for measurements of fore- and hind wings, respectively, from different host species).

Legs. Foretibia with one row of about 7 thick and another row of about 7 more slender sensilla chaetica. Hind tarsomere 1 about 1.32 (1.28-1.37, n=3) times as long as tarsomere 2.

Metasoma. Ovipositor length 2.09-2.64 times hind tibial length, extending under mesosoma to apex of forecoxa (see Table XII for measurements from different host species). Gaster elongate and somewhat pointed apically (Fig. 36), with a gap between cercus and apex about equal to length of cercus.

Male. Total length of flagellum 746 (556-858, n=9). Length of antennal segments (n=8-11): scape 110 (90-116), pedicel 48 (43-53), Fl_1 10 (7-11), Fl_2 72 (53-83), Fl_3 77 (59-92), Fl_4 75 (56-88), Fl_5 74 (55-90), Fl_6 73 (56-86), Fl_7 71 (56-81), Fl_8 72 (51-85), Fl_9 71 (50-83), Fl_{10} 70 (52-81), Fl_{11} 76 (57-89). Fl_6 length/width ratio averaging 3.67, with 5 longitudinal sensilla. Males were reared from *S. destructor*, *S. pertinax* and *S. venatus vestitum* only

Variation. There is apparently little structural variation among specimens reared from different hosts. The greatest variation is in body size, with some of the largest individuals (ex. *S. maidis*) being twice as long as some of the smallest (ex. *S. minimus* and *S. parvulus*)

Distribution. USA (FL, HI, MO, MS, OH) .

Material examined (all in USNM unless otherwise indicated). **CANADA. Ontario**. Toronto, Etobicoke, Islington Ave., Barclay Terrace mansion, vii-viii.2004, YPT, S.V. Libenson (2♀ ♀ on cards, CNCI). **USA. Florida**. Broward Co.: Fort Lauderdale, vii.1968, H. Nakao and R. Suzukawa, ex. *Sphenophorus venatus vestitus* (9♀ ♀, 1♂). **Hawaii**. Oahu: Honolulu, laboratory reared, 2.ii.1968. J.W. Beardsley (1♀, 1♂, BPBM); University of Hawaii Campus, Gilmore Hall, 27.iv.1986, L. LeBeck (1♂, CNCI); Hilo Coast, Kolekole Beach Park, 19.x.1983, D.M. LaSalle (1♀, CNCI). **Mississippi**. Grenada Co.: Grenada, 23.vi.1922, H.E. Roberts, ex. *S. destructor* (1♀), 16-22.vi.1922 (1♂); Washington Co.: Greenville, 15.vi.1922, A.F. Satterthwait,

ex. *S. destructor* (1♀), 15-22.vi.1922, J.L.E. Laverdale, ex *S. destructor* (1♀). **Missouri.** St. Louis Co.: Kirkwood, lab. reared, no date, A.F. Satterthwait, ex. *S. destructor* (5♀ ♀, 1♂); Kirkwood, no date, ex. *S. destructor* A.F. Satterthwait (1♀); Kirkwood Station, 3.vii.1924, ex. *S. parvulus* on timothy in field (5♀ ♀), 4 and 23.vii and 1 and 2.viii.1924, A.F. Satterthwait, ex. *S. parvulus* in lab. (12♀ ♀); Kirkwood Station, 3 and 4.viii.1924, A.F. Satterthwait, ex. *S. callosa* (4♀ ♀) and 3 with no date, ex. *S. callosa*; Kirkwood, 1-4.viii.1924, A.F. Satterthwait, ex. *S. pertinax* (17♀ ♀, 4 ♂); Kirkwood, 3.vii.1924, A.F. Satterthwait, ex. *S. minimus* in field on *Agrostis alba* (8♀ ♀, 1 ♂); Kirkwood, 14, 15, and 17.viii.1924, A.F. Satterthwait, ex. *S. minimus* (5♀ ♀); Kirkwood, 18, 20, 22, and 25.viii.1924, A.F. Satterthwait, ex. *S. costipennis* (18♀ ♀, 1♂); Kirkwood, no date, A.F. Satterthwait, ex. *S. maidis* (3♀ ♀); Webster Groves, 10.viii.1922, H.E. Roberts, ex. *S. parvulus* (3♀ ♀); Webster Groves, 9.vii.1923, H.E. Roberts, ex. *S. callosa* (1♀), 2-23 and 10-22.vii.1922, H.E. Roberts, ex. *S. callosa* (2♀ ♀); Webster Groves, 22.vii.1924, A.F. Satterthwait (1♀ ♀); Webster Groves, 15.vii.1925, H.E. Roberts, ex. *S. minimus* (4♀ ♀, 1♂). **Ohio.** Wayne Co.: Wooster, O.A.R.D.C., 21.vi.1976, C. Frost (5♀ ♀, 3♂ ♂).

Hosts and Biology. *Anaphes calendrae* is a gregarious parasitoid of *Sphenophorus* species (Curculionidae: Rhynchophorinae), commonly known as billbugs (Vaurie 1951). Up to nine individuals have been reared from a single host egg. Usually seven larvae (one male and six females) develop per host egg and there are four to seven broods per year (Satterthwait 1931). The original series from which laboratory rearings were initiated was field collected at Kirkwood [Station] from the egg of *S. parvulus* (Gyllenhal) on timothy and from eggs of *S. ?minimus* Hart. The species was reared through several generations on different *Sphenophorus* hosts at the Webster Groves field laboratory. Satterthwait (1931) found that *A. calendrae* destroyed 75% of *S. minimus* and *S. parvulus* eggs in white bent grass, *Agrostis alba*. Other field collected hosts were *S. callosus* (Gyllenhal) and *S. destructor* Chittenden. Under laboratory conditions, *S. costipennis* Horn, *S. australis* Chittenden, *S. maidis* Chittenden, *S. necydaloides* Chittenden, and *S. venatus* (Say) were successfully parasitized (Vaurie 1951). *Anaphes calendrae* was introduced into Hawaii in an attempt to control *Sphenophorus cariosus* (Olivier) (Beardsley 2000). Under insectary conditions, *A. calendrae* was reared on *S. cariosus* and *S. venatus vestitus* Chittenden and it is presumed that these hosts are also attacked in the field (Beardsley 2000). Over 74,000 specimens from Florida and Missouri were successfully propagated for release in Hawaii (Anonymous 1970). A prior attempt to establish *A. calendrae* against the New Guinea sugarcane weevil, *Rabdocnemis obscura* Boisduval, in Hawaii failed so this species is probably not a host, despite being cited as such by Thompson (1958). Nevertheless, it is capable of parasitizing *R. obscura* eggs in the laboratory (Bianchi 1964).

Anaphes confertus Doutt
(Figs. 3, 18, 37)

Anaphoidea conferta Doutt, 1949: 155 (original description).
Patasson conferta; Burks, 1958: 63 (catalog).
Patasson confertus; Peck, 1963: 32 (catalog); Burks, 1979: 1030 (catalog).
Anaphes conferta; Schauff, 1984b: 216 (comparison with *diana*)
Anaphes confertus; Huber, 1992: 155 (list).

Type material. HOLOTYPE ♀ (CASC), examined. On slide labelled: 1. "by sweeping native

vegetation Oakville, Napa Co., Calif. May 3, 1948 R.L. Doutt". 2."*Anaphoidea conferta* Doutt ♀ Type" (red label). 3."California Academy of Sciences Entomology Type No.17134" (on back of slide). The holotype is in rather poor condition, mounted laterally, with head ventral side up, detached and broken, wings except left hind wing detached, antennae detached from head and one broken into two pieces at pedicel, and right hind leg detached. Measurements are given in Table I.

Diagnosis. Scape (Fig. 3) strongly convex ventrally, at most about 3.5 times as long as wide; pedicel longer than Fl_1 and Fl_2 together; funicle segments at most 1.5 times as long as wide; clava longer than Fl_4 – Fl_6 together; ovipositor less than 0.9 times length of hind tibia, not produced under mesosoma (Fig. 37).

Description. Female. *Colour.* Body brown. Antenna and legs pale brownish-yellow. Forewing (Fig.18) narrowly brown along entire margin.

Body length. 498 (465-525, n=4, from critical point dried specimens).

Head. Width 202 (180-215, n=4). Occipital suture straight (as in Fig. 30). Ocellar setae at least as long as diameter of anterior ocellus.

Antenna. Scape with ventral margin strongly convex, its inner surface with faint, obliquely transverse reticulations. Pedicel longer than Fl_1 and Fl_2 together. No funicle segment more than 1.5 times as long as wide (or exceptionally so). Fl_1 as wide at base as at apex. Fl_3, Fl_5 and Fl_6 each with 2 longitudinal sensilla (Fig. 3). Clava longer than Fl_4 – Fl_6 together. Measurements are given in Table XIII.

Mesosoma. Pronotum with long, fine setae. Mesonotum moderately long setae.

Wings. Forewing length 722 (664-758, n=4), width 114 (103-125), FWL/FWW 6.43 (6.05-7.10), LMC 168 (159-174), their length at least one-fifth greater than forewing width; marginal space 107 (80-143), medial space narrow, cubital line of setae uniformly close to posterior margin of wing. Hind wing length 683 (628-712, n=4), width 33 (29-37), with 6-17 microtrichia medially on blade in apical half, LMC 130 (72-133).

Legs. Foretibia with 9-12 sensilla chaetica. Hind tarsomere 0.86 times (n=1) as long as tarsomere 2.

Metasoma. Ovipositor not extending forward under mesosoma (Fig. 37), its length 179 (169-187, n=3), at most 0.9 times length of hind tibia. Gaster blunt apically (Fig. 37).

Male. Unknown.

Distribution. Canada (BC, ON), USA (AZ, CA, GA, TX).

Material examined. 13 ♀ ♀ (3 on slides). **CANADA. British Columbia:** Upper Carmanah Valley, UTM 10U CJ 803006, 12-27.viii and 16-30.vii.1991, N. Winchester, TZ MT5 (2♀ ♀, CNCI). **Ontario:** 6 km NNE Egansville, Shaw Forest, 45°138'N 77°04'W, 1-8.vii.1993, H. Goulet ♀ M. Sharkey, FIT (1♀, CNCI). **USA. Arizona.** Cochise Co.: 12 km S. Sierra Vista, Ramsay Canyon, 10.vi.1987, B.V. Brown, Malaise, oak/pine (1♀, CNCI); Santa Cruz Co.: Patagonia, 31°32'52"N 110°46'03"W, 10-15.v, and 1-5.vi.1994, B. Brown ♀ E. Wilk (4♀ ♀, CNCI). **California.** Santa Barbara Co.: Santa Barbara, Lu Vista Road, 1-4.iv.1982, S. Miller, pan trap (1♀, CNCI); Santa Cruz Island between Alamos Canyon and Centinela, 21.iii.1982, J.T. Huber, sweeping (1♀, UCRC); Stanislaus Co.: Newman, 21.iv.1949, sweeping low vegetation near Merced River, R.L. Doutt (1♀, EMEC). **Georgia.** Liberty Co.: St. Catherines Island, 6-10.iv.1995, A. Sharkov, MT, road between Windmill and Gator Pond (1♀, UCRC). **Texas.**

Brazos Co.: College Station, 14.iii-2.iv.1987, R. Anderson, post oak savannah (1♀, CNCI).
Hosts and Biology. Unknown.

Anaphes conotracheli Girault
(Figs. 4, 19, 32, 38)

Anaphes conotracheli Girault, 1905: 220 (original description); Johnson and Girault, 1906: 5 (distribution, percent parasitism); Quaintance, 1906: 327 (parasitism rate); Girault, 1907: 29 (host); Pierce, 1908: 43 (host); Girault, 1909: 171 (removal to *Anaphoidea*); Brooks, 1910: 110 (parasitism rate); Viereck 1910: 637 (host); Brooks, 1911: 137 (parasitism rate); Ogloblin, 1939: 144 (mention): Richards and Davies, 1977: 1225 (mention); Huber *et al.*, 1997: 969 (incorrect host record).

Anaphes (*Anaphoidea*) *conotracheli*; Viereck, 1916: 447 (redescription); Snapp, 1930: 77 (host).

Anaphea conotracheli; Solomon, 1985: 12 (host).

Anaphoidea conotracheli; Girault, 1910: 248 (redescription, comparison with *pullicrurus* and *sordidata*, collection localities); Pierce, 1910: 453 (example of simple endoparasitism); Girault, 1911a: 216 (comparison with *diana*); Girault, 1911b: 148 (transfer from *Anaphes* to *Anaphoidea*); Girault, 1911e: 323 (list); Girault, 1912: 153 (comparison with *A. linnaei*); Quaintance and Jenne, 1912: 140 (distribution, life cycle, parasitism rate); Marcovitch, 1916: 140 (host); Girault, 1917: 93 (host); Brooks, 1918: 14 (parasitism rate); Washburn, 1919: 184 (host); Britton, 1920: 323 (list); Porter, 1922: 165 (percent parasitism); Girault, 1929: 12 (key); Alden, 1930: 19 (mention); Dozier *et al.*, 1932: 38 (parasitism rate); Doutt, 1949: 160 (key); Soyka, 1949: 359 (German translation of original description); Garman *et al.*, 1953: 7 (host); Jackson, 1956: 145 (incorrect host record); Thompson, 1958: 569 (host list); Collins and Grafius, 1983: 1 (host).

Anaphoides conotracheli; Dozier and Williams, 1929: 36 (host).

Anaphoidia conotracheli; Moultrie, 1952: 19 (host).

Patasson conotracheli; Peck, 1951: 414 (catalog, hosts); Peck, 1963: 32 (catalog, hosts); Burks, 1967: 214 (*luna* deleted as a synonym); Burks, 1979: 1030 (catalog); Arnett, 1985: 435 (host); Davidson and Lyon, 1987: 426 (hosts).

Anaphes sp. possibly *conotracheli*; Tedders and Payne, 1986: 986.

Patasson (*Anaphoidea*) *conotracheli*; Garman and Townsend, 1952: 3, 63 (hosts).

Type material. HOLOTYPE ♀ (USNM), examined. On card point labelled as follows: 1. "♂". 2." on *Conotrachelus nenuphar* eggs". 3."Arundel. Md. v.20.1905". 4."A.A. Girault Collector". 5."♀ Type No. 8433 U.S.N.M." 6."*Anaphes conotracheli* Girault". The specimen has the head and antennae missing. The date of capture of this specimen was incorrectly cited by Girault (1905) as v.16. Clearly, he mixed up the dates and places of capture for the specimens from Arundel, MD, and Tryon, NC (collected on 20.v). PARATYPES. One female and 5 males under one coverslip on slide labelled 1."*Anaphes* species on eggs Cono. nenuphar Ft. Valley, Ga. V.10.1905, Quaintance Coll Girault reared 4♂ 2♀ No. 44104 Balsam no. 60 [crossed out] 31434". 2."Homotype ♀ Plesiotype". 2."*Anaphoidea conotracheli sordidata* [crossed out] (Girault) Cotypes. 44104." Girault (1905) described *A. conotracheli* from 40 specimens and stated: "type deposited in the United States National Museum". I treat this as a valid holotype designation according to article 73.1.1 of the ICNZ (1999), particularly because only one

specimen is labelled "type" and several (but not all) the others mentioned by Girault are labelled as paratypes. I slide-mounted three (2♀ and 1♂) of the original point-mounted specimens and used one paratype from Fort Valley, Georgia, for the measurements given in Table I.

Diagnosis. Occipital suture angled inwards towards dorsal margin of occipital foramen (Fig. 32); Fl_3-Fl_6 usually each with 2 longitudinal sensilla; forewing with part of posterior margin hyaline medially, preceded and followed by a narrow dark margin and another short, clear area on posteroapical curve almost to apex that abruptly changes to a dark margin along anteroapical curve (Fig. 19); ovipositor extending forward under mesosoma at least to the apex of forecoxa and basal loop very tight, with dorsal arm almost parallel to ventral arm (Fig. 38).

Among the described Nearctic species of the *crassicornis* group the oblique occipital suture and dark and light border of the posterior margin of the forewing distinguish *A. brunneus*, *A. conotracheli*, and *A. pallipes* from the remaining described species, which all have a straight occipital suture and uniformly dark posterior margin of the forewing. The only feature that apparently distinguishes *A. conotracheli* from *A. pallipes* is the presence in *A. conotracheli* of 1 or, usually, 2 longitudinal sensilla on Fl_4 (none in *A. pallipes*). *Anaphes pallipes* is also smaller than *A. conotracheli*. The only features that distinguish *A. conotracheli* from *A. brunneus* are the relatively shorter and broader Fl_2, with a ratio of at most 3.3 (at least 4.4 in *A. brunneus*), and the ovipositor/hind tibia ratio of at least 1.8 (1.62 in *A. brunneus*).

Description. Female. *Colour* (from four point-mounted paratypes). Body brown. Legs almost white except coxae, femora in middle, and tarsomere 4 light brown. Forewing (Fig. 19) with posterior margin clear to apex of wing or at least distinctly lighter brown than anterior margin, except for a short brown section subapically.

Body length. 536 µm (460-620, n= 11, from slide-mounted specimens from GA, MD, VA).

Head. Width 221 (189-238, n=12). Occipital suture short, angled inwards towards dorsal margin of occipital foramen (Fig. 32)

Antenna. Inner surface of scape and pedicel with distinct, oblique cross striations. Fl_3, Fl_5 and Fl_6 each with 2 longitudinal sensilla, Fl_4 usually with 2 sensilla (Fig. 4) but sometimes (one third of the specimens measured) with 1 sensillum. Measurements are given in Table XIV.

Mesosoma. Pronotum and mesonotum with short, inconspicuous setae.

Wings. Forewing length 661 (592-704, n=14), width 141 (124-154), FWL/FWW 4.70 (4.43-5.15), LMC 127 (108-140); marginal space 107 (80-143), medial space triangular; cubital line of setae closest to posterior margin of wing near retinacular seta, then diverging away until separated by at least one setal length from posterior margin. Hind wing length 644 (633-671, n=10), width 29 (24-32), with 0-4 (usually only with 1) microtrichia medially on blade in apical half, LMC 106 (90-115).

Legs. Foretibia with 8-11 sensilla chaetica. Hind tarsomere 0.76 (0.70-0.82, n=10) times as long as hind tarsomere 2.

Metasoma. Ovipositor length 420 (365-470, n=14), 1.95 (1.8-2.1) times as long as hind tibia. Gaster appearing relatively short compared to mesosoma.

Male. Total length of flagellum 717µm (650-796, n=10). Length of antennal segments (n=10): scape 87 (77-92), pedicel 44 (37-50), Fl_1 8 (7-9), Fl_2 65 (58-73), Fl_3 73 (63-80), Fl_4 70 (60-77), Fl_5 71 (62-79), Fl_6 71 (62-80), Fl_7 71 (60-80), Fl_8 71 (61-78), Fl_9 72 (62-81), Fl_{10} 72 (65-82), Fl_{11} 71 (67-84). Fl_6 length/width ratio averaging 2.73, with 5 longitudinal sensilla. Gaster appearing very short relative to mesosomal length.

Variation. Females sometimes have only 1 longitudinal sensillum on Fl_4 [2 specimens from

Blacksburg, VA, ex. *Hypera nigrirostris* (Fabricius) (slide in USNM) and some specimens from Ste. Clotilde, QU, ex. *Conotrachelus geminatus* (LeConte) (slides in CNCI)]. This segment is consequently slightly shorter and narrower than Fl_3. However, the series of specimens from Monticello, collected by Dozier, neatly bridges the gap between *A. pallipes* and *A. conotracheli* because one female has both Fl_4 with 2 longitudinal sensilla, and the other two females have one Fl_4 without longitudinal sensilla and one with 1 longitudinal sensillum. Probably only one species is involved, with larger individuals parasitizing the larger eggs of *Conotrachelus* and smaller individuals parasitizing the smaller eggs of *Cylindricopturus*. The differences in the specimens reared from these two host genera parallels the differences found for *A. iole* and one of its synonyms reared from large and small mirid hosts. In the latter case, experimental support showed only one species was involved so the synonymy could be made with certainty (Huber and Rajakulendran 1988). Until such support is available for *A. conotracheli* and *A. pallipes* I retain the two species as distinct, mainly because a relatively large body of literature is associated with *A. conotracheli*. If crossing experiments show that the species are the same (as I suspect) then the name *A. pallipes* would have priority.

Comments. Normally, the most common species from an area are collected first and usually described soon after. Passive collecting methods, such as pan or Malaise trapping that yield large amounts of material, were unknown or not used in Ashmead's and Girault's time. Rather, collecting consisted of sweeping and, in Girault's case, searching panes of glass in greenhouses etc., or else host eggs were searched for and parasitoids reared from them. Thus, species, particularly economically important ones, that tend to search for hosts on aerial parts of plants (e.g. *Cylindrocopturus adspersus* on sunflower, *Conotrachelus nenuphar* on plum) would most likely be collected first, before species that search for host eggs near or at ground level. It is therefore not coincidental that the first two *Anaphes* species described from North America were *A. pallipes* and *A. conotracheli*, precisely those species of *Anaphes* most likely to be collected by sweeping, searching glass panes, or rearing eggs laid in easily accessible locations.

Distribution. Canada (QC), USA (DC, GA, IL, MD, VA, WV). In addition, Johnson & Girault (1906) reported *A. conotracheli* from CT, KY, NC, and TX.

Material Examined. 46♀ ♀ and 35♂ ♂ (42 on slides). **CANADA. Quebec.** Ste. Clotilde, vii, 20.vii, viii, and 1-23.viii.1990, S. Côté (33♀, 24♂, CNCI). **USA. District of Columbia**. No. 1100 and 1271, A.A. Girault [no date or locality given, possibly those bred at Washington as mentioned in original description] (1♀, 1♂, and 1 specimen in egg, USNM). **Georgia.** Peach Co.: Fort Valley, 9.v.1905, A.L. Quaintance and 9.vi.1924, O.J. ?Snaph (4♀, 1♂, USNM). **Illinois.** Cook Co.: Chicago, Clayton Smith Forest Preserve, 31.vii.1989, J.D. Pinto (1♀, CNCI); Effingham Co.: SSW. Mason, 7.ix.1993, J.D. Pinto (1♂, CNCI); Piatt Co.: Monticello, swept from vegetation along Sangamon river, 31.vii.1932, H.L. Dozier (3♀, 4 ♂, USNM). **Maryland.** Anne Arundel Co.: 16.v.1905, A.A. Girault (1♀, 1♂, USNM). *Virginia.* Fairfax Co.: Vienna, 16.v.1913, R.A. Cushman (1♀, 2♂, USNM); exact locality not given, 25.iv.1921, sent in by W.J. Schoene of Blacksburg (2♀, 6♂, USNM). **West Virginia**. Upshur Co.: French Creek, no date, E.E. Brooks (5♀, 1♂, USNM).

Hosts and Biology. *Conotrachelus geminatus* on *Bidens cernua* L., *C. nenuphar* (Herbst) (plum curculio) (Girault 1905), *Craponius inaequalis* (Say) (grape curculio) (Porter 1922). *Hypera nigrirostris* (lesser clover leaf weevil). Specimens reared from *C. geminatus* collected in the field at Ste. Clotilde, QC, were successfully maintained for eight generations on *Listronotus oregonensis*

eggs in a laboratory colony at St-Jean-sur-Richelieu. No *A. conotracheli* were ever found on the latter host in the field.

Quaintance (1906) reported 60-70% egg parasitism of *C. nenuphar* on peaches in Georgia, and Johnson and Girault (1906) reported 16-70% parasitism. Brooks (1918) reported 39.5% egg parasitism of *C. inaequalis* on grapes. Marcovitch (1916) reported the sawfly *Aprosthena zabriskei* Webster & Malley (Argidae) on *Portulaca oleracea* L. as a host. The two specimens were identified by Girault but vouchers were not seen. If correctly identified, this would be the first published record of an *Anaphes* species reared from a species of Hymenoptera. Tedders and Payne (1986) recorded a species of *Anaphes*, possibly *conotracheli*, from *C. schoofi* Papp but voucher specimens were not seen. Garman and Townsend (1952) listed *Conotrachelus nenuphar* (Curculionidae) and *Rhagoletis pomonella* (Walsh) (apple maggot) (Tephritidae) as hosts. The host record of *C. anaglypticus* (Say) on *Thalictrum pubescens* Pursh. by Huber *et al.* (1997) is incorrect.

Comments. The references to *A. conotracheli* by Porter and Alden (1921), Porter (1922), Schauff (1984a: 48), probably Porter (1928), Charlet and Balsbaugh (1984), and Solomon (1985) refer to *A. pallipes* as defined under that species below. I examined voucher specimens and compared them to the type of *A. pallipes*. Bakkendorf (1934) reared a species in Europe from dytiscid and chrysomelid eggs which he referred to as *A. conotracheli* but the specimens he reared from *Agabus* (Dytiscidae), and almost certainly also those reared from Chrysomelidae, are very likely misidentified and probably represent two species, neither of them *A. conotracheli*. Jackson (1956) noted that specimens she reared from *Agabus* sp. were not the same as *A. conotracheli*.

Anaphes cotei Huber

(Figs. 5, 20, 39)

Anaphes cotei Huber *et al.*,1997: 970 (original description).

Type Material. HOLOTYPE ♀ (CNCI), examined (see Huber 1997), from CANADA: Nova Scotia, Great Village.

Distribution. Canada (NS).

Diagnosis. Statistics of the antennal segments are given in Table XV to complement the description in Huber *et al.* (1997) and for comparison with the antennal descriptions of the other species redescribed here. Type measurements are given in Table I. The species is most similar to *A. pullicrurus*. *Anaphes cotei* has a relatively narrow forewing (Fig. 20) as in *A. pullicrurus* (Fig. 27) but the inner surface of the scape has bluntly pointed, oblique scales with slightly thickened apices, as in *A. gerrisophaga* (scales not clearly visible in *A. pullicrurus*). The antenna (Fig. 5) has 2 longitudinal sensilla on Fl_4, as in *A. pullicrurus* (Fig. 13) but each funicle segment is relatively longer and more slender than in *A. pullicrurus*.

Anaphes diana (Girault)

(Figs. 6, 21, 40)

Anaphoidea diana Girault, 1911a: 215 (original description); Girault, 1914b: 109 (contrast with *luna*); Girault, 1929: 12 (contrast with *conotracheli*); Soyka, 1949: 362 (description, comparison with *conotracheli*); Schauff, 1984b: 214 (mention).

Anaphes diana; Schauff, 1984b: 214 (diagnosis); Schauff 1984a: 48 (types examined); Yeargan, 1985: 528 (release in Delaware and Kentucky); Aeschlimann, 1986: 164 (distribution,

parasitism rate); Huber, 1986: 197 (biocontrol in Australia); Aeschlimann *et al.*, 1989: 418 (rearing, release and recovery in Australia); Worner *et al.*, 1989: 1086 (climate tolerance limits); Aeschlimann, 1990: 3 (thelytokous and arrhenotokous populations); Dysart, 1990: 307 (release and recovery in USA); Chiriac and Poiras, 1995: 39 (occurrence in Moldova); Pagliano, 1995: 35 (Italian checklist).

Anaphes (*Anaphes*) *diana*; Baquero and Jordana, 2002: 79 (distribution, hosts).

Anaphes (*Patasson*) *diana*; Fitton *et al.*, 1978: 110 (British checklist); Viggiani, 1994: 474 (male genitalia).

Patasson diana; Richards and Waloff, 1965: 202 (host); Aeschlimann, 1975: 407 (mention); Collins and Grafius, 1983: 1 (host).

Anaphes (*Patasson*) *lameerei* Debauche, 1948: 182 (original description); Hincks, 1960: 213 (diagnosis, British distribution); Fitton *et al.*, 1978: 110 (checklist); Schauff, 1984b: 214 (synonymy with *A. diana*); Yeargan, 1985: 528 (old name for *diana*).

Anaphes lameerei; Hellén, 1974: 27 (redescription, distribution); Schauff, 1984a: 48 (types examined).

Patasson lameerei; Aeschlimann, 1975: 405 (host, distribution, parasitism rate); Dysart and Bingham, 1976: 29 (introduction into USA); Aeschlimann, 1977: 111 (life history); Hopkins, 1978a: 1 (life cycle, release in Australia, rearing difficulties); Leibee *et al.*, 1979: 354 (development rate); Aeschlimann, 1980: 146 (parasitism rate); Bloem, 1980:1 (biology);Yeargan and Shuck, 1981: 119 (longevity, reproductive rate); Bloem and Yeargan, 1982a: 37 (temperature effects on survival); Bloem and Yeargan, 1982b: 93 (host finding behavior); Collins and Grafius, 1983: 1 (host); Aeschlimann, 1986: 164 (synonymy quoted); Aeschlimann *et al.*, 1989: 418 (release in Australia); Worner *et al.*, 1989: 1085 (synomymy mentioned).

Type Material. LECTOTYPE♀ (USNM), examined. On slide labelled: 1."Fred Enock Preparer Order Hymenoptera Family Mymaridae Genus *Eustochus* Species *atripennis* ♀". 2."A fairy fly. Spot Lens 2 inch to 1/2 inch. Type 13,663 [in pencil] *Anaphoidea diana* Gir. [in ink]". 3. "PARALECTOTYPE *Anaphoidea diana*, des. Schauff-83". The lectotype is in good condition but uncleared, and mounted dorsal side up with appendages spread out. Measurements are given in Table I. PARALECTOTYPE ♂ (USNM) same data as holotype. *Anaphoidea diana* Gir. Type No. 13663 U.S.N.M." 4. "Paralectotype Schauff-83".

DIAGNOSIS. Fl_2 at most 2.7 times as long as broad and 1.7 times as long as Fl_1 (Fig. 6); ovipositor shorter than hind tibial length and not extending to base of gaster (Fig. 40).

DESCRIPTION. female. *Colour.* Dark brown; scape and pedicel lighter, especially ventrally, legs lighter except usually tibiae and femora medially. Forewing (Fig. 21) with posterior margin uniformly brown.

Body length. 387µm (322-434, n=10).

Head. Width 192 (187-204, n=10). Occipital suture straight (as in Fig. 30).

Antenna. Fl_3, Fl_5 and Fl_6 each with 2 longitudinal sensilla (Fig. 6), Fl_4 usually with 1 but sometimes (one third of specimens measured) with 1 sensillum, and occasionally (one fifth of specimens measured) without sensilla. One specimen had no longitudinal sensilla on one antenna and 1 on the other. Measurements are given in Table XVI.

Mesosoma. Pronotum and mesonotum with short, inconspicuous setae.

Wings. Forewing length 559 (529-618, n=10), width 75 (68-82), FWL/FWW 7.53 (7.17-

8.63), LMC 125 (117-140); marginal space 98 (74-125), medial space triangular, cubital line of setae next to posterior margin of wing for entire length. Hind wing length 548 (507-604, n=10), width 23 (21-26), with 1-8 microtrichiae medially on blade in apical half, LMC 100 (91-109).

Legs. Foretibia with about 9-11 sensilla chaetica. Hind tarsomere 1 about 0.77 times as long as hind tarsomere 2.

Metasoma. Ovipositor length 126 (115-148, n=14), 0.64 (0.61-0.67) times as long as hind tibia. Gaster shorter than mesosoma (0.86: 1) and bluntly rounded apically.

Male. Total length of flagellum 698 (624-749, n=8) (paralectotype flagellum 652 long). Length of antennal segments (n=7 or 8): scape 85 (80-92), pedicel 41 (38-47), Fl_1 5 (4-5), Fl_2 59 (52-65), Fl_3 66 (58-73), Fl_4 70 (61-75), Fl_5 72 (66-76), Fl_6 70 (63-75), Fl_7 72 (66-75), Fl_8 71 (64-76), Fl_9 73 (65-79), Fl_{10} 68 (59-74), Fl_{11} 72 (64-80). Fl_6 length/width ratio averaging 3.68, with 5 longitudinal sensilla.

DISTRIBUTION. Europe, southwestern Asia (Aeschlimann 1986), Canada (QC). Importations of *A. diana* into the US were made in the mid 1970's. Releases were made in USA (DE, ID, KY) but establishment is uncertain (Yeargan 1985).

MATERIAL EXAMINED. 90 ♀♀ and 46 ♂♂ (60 on slides). **CANADA. Quebec.** no locality given, 28.vii.1979, M.E. Schauff & E.E. Grissell (2♀, CNCI). **FRANCE. Hérault:** Lattes, 23.iii.1976, ex. *Sitona humeralis* (1♀, 1♂, CNCI); Montpellier, ex. lab. culture at CSIRO lab., 1977 (6♀, 6♂, CNCI); St. Gely-du-Fesc, iii.1984 (43♀, 20♂, CNCI); Vestrie, 13.iv.1976 (1♂, CNCI); Viols-Le-Fort, 21.iii.1976 (1♀, CNCI).**USA. Idaho.** Latah Co.: Moscow, 12vi.1979, D.J. Schotzko, ex. lab. colony on *Sitona lineatus* (4♀, CNCI). **Kentucky.** Fayette Co.: Lexington, 12.vi.1980, K.A. Bloem, ex. lab. colony on *Sitona hispidulus* (51♀, 26♂, CNCI, USNM).

Hosts And Biology. *Sitona hispidulus* (Fabricius), the clover root curculio (Yeargan, 1985), *S. humeralis* Stephens, and *S. lineatus* (Aeschlimann, 1980).

Aeschlimann (1986) reported 1.9-23.9% parasitism in *Sitona* populations sampled in various countries. The species was also able to complete development in *S. cylindricollis* Fåhraeus and *S. flavescens* (Marsham) in the laboratory (W. Day, Newark, Delaware, personal communication). One generation takes about 11-13 days at 26.7°C (Leibee *et al.* 1979). Both thelytokous and bisexual populations may occur at the same locality (Aeschlimann 1990). Dysart and Bingham (1976) imported field collected *A. diana* from Département of Yvelines, France, into North America. It was first released against the local *Sitona* spp., primarily *S. hispidulus*, in an alfalfa field at the Beneficial Insects Laboratory, Newark, Delaware, during spring, 1976, and again in 1977. In total, 4009 adults were released. Laboratory reared, parasitized host eggs were also sent to cooperators in Moscow, ID, Urbana, IL, and Lexington, KY, for rearing and release. In 1978 and 1979, 7396 and 409 *A. diana*, originating from France and Austria, were released at Newark and, in 1979, another 1000 adults from France were released in Fayette Co., KY. By 1986, after several years of recovery attempts from field-collected *S. hispidulus* eggs, only three specimens had been found, suggesting that it had established, albeit at an extremely low parasitism rate. The two specimens from Nova Scotia (CNCI, point-mounted) appear to be *A. diana* but are slightly larger. They are tentatively treated as this species. The two Quebec specimens almost certainly are *A. diana*. It would be useful to rear specimens from eggs of *Sitona* in Quebec and Nova Scotia and cross them with European specimens (or North American lab. colonies obtained from Europe) reared from *Sitona* to determine if they are indeed the same

species. If they are the same then the species probably already occured in North America prior to deliberate introductions into the USA. This would not be surprising as the host plants were deliberately introduced long ago as forage crops and at least five species of *Sitona* (*cylindricollis*, *hispidulus*, *lineatus*, *lineellus* (Bonsdorff), and *tibialis* (Herbst)) were accidentally introduced and established in North America.

Anaphes gerrisophagus (Doutt)

(Figs. 7, 22, 41)

Anaphoidea gerrisophaga Doutt, 1949: 156 (original description).
Patasson gerrisophaga; Burks, 1958: 63 (catalog).
Patasson gerrisophagus; Peck, 1963: 34 (catalog, host); Burks, 1979: 1030 (catalog).
Anaphes gerrisophagus; Huber, 1992: 74 (list).
Anaphes pullicrura; Scotland, 1940: 325 (misidentification, list).

Type Material. HOLOTYPE ♀ (CASC), examined. On slide labelled: 1. "Ex. *Gerris* eggs Lake Britton Shasta Co., Calif. 29 June 1947 R L Usinger." 2."*Anaphoidea gerrisophaga* Doutt ♀ Type" (red label). 3.(on back of slide) "California Academy of Sciences Entomology Type No. 17135". The holotype is in good condition, dorsal side up, with head detached and face up. Its measurements are given in Table I. PARATYPE ♀ (EMEC), examined. Labelled 1."On window El Cerrito, Calif. June 11, 1948 R.L. Doutt." 2."*Anaphoidea gerrisophaga* Doutt ♀ Paratype". The paratype is in good condition, dorsal side up, with left wing and right antenna detached.

Diagnosis. Forewing very narrow, FWL/FWW greater than about 8.3 (Fig. 22). Vertex, pronotum and mesonotum with long, strong setae (Fig. 41). *Anaphes pullicrurus* and *A. cotei* also have relatively narrow wings (FWL/FWW up to 8.59) but the setae on the vertex and mesonotum are short and inconspicouous (the head setae on the holotype of *A. pullicrurus* are missing so their size is unknown). The narrow wings of *A. gerrisophaga* also resemble those of *A. sinipennis* Girault (in the *fuscipennis* species group), but the clava in *A. sinipennis* is entire and bluntly rounded apically instead of being divided and more pointed.

Description. Female. *Colour* (from uncleared type slides). Brown with antennae and legs slightly ligher. Forewing (Fig. 22) narrowly brown along posterior margin but slightly lighter than along anterior margin. Medial space appearing as a lighter longitudinal line between anterior, posterior and apical infuscate areas of disc.

Body length. 503µm (378-594, n=8, from critical point dried specimens).

Head. Width 172 (145-198, n=7). Occipital suture straight (as in Fig. 30). Ocellar setae at least half as long as distance between posterior ocelli (distinctly longer than diameter of anterior ocellus).

Antenna. Scape with ventral margin slightly, evenly convex, and inner surface with faint curved oblique striations, some with slight thickenings medially. Fl_5 and Fl_6 each with 2 longitudinal sensilla (Fig. 7); Fl_3 with 2 longitudinal sensilla in most specimens but one specimen with only 1 longitudinal sensillum on one antenna and 2 longitudinal sensilla on the other; Fl_4 either without or with 2 longitudinal sensilla. The holotype has 1 longitudinal sensillum on one antenna and none on the other. Measurements are given in Table XVII.

Mesosoma. Pronotum and mesonotum with conspicuous, long and erect setae (Fig. 41).

Wings. Forewing length 632µm (472-838, n=13), width 67 (55-100), FWL/FWW 9.21 (8.37-10.04), LMC 133 (93-172), their length about twice forewing width; marginal space 106

(67-167), medial space long and narrow, somewhat rectangular and extending medially about halfway along wing, cubital line of setae uniformly close to posterior margin. Hind wing length 613 (467-793, n=13), width 22 (16-29, n=14), with 6-8 microtrichia medially on blade in apical half, LMC 108 (87-135).

Legs. Foretibia with about 4-7 sensilla chaetica. Hind tarsomere 1 1.05 (1.00-1.08, n=3) times as long as tarsomere 2.

Metasoma. Ovipositor length 270 (212-344, n=11), 1.31 (1.05-1.43, n=11) times length of hind tibia, extending under mesosoma to base of mesocoxa (Fig. 41).

Male. Total length of flagellum 803. Length of antennal segments (n=1, specimen from Ithaca, NY, on *Lemna*): scape (not measureable), pedicel 41, Fl_1 5, Fl_2 79, Fl_3 81, Fl_4 81, Fl_5 83, Fl_6 82, Fl_7 76, Fl_8 78, Fl_9 82, Fl_{10} 80, Fl_{11} 82. Fl_6 length/width ratio averaging 4.32, with 5 longitudinal sensilla.

Variation. *Anaphes gerrisophaga* appears to be quite variable in size. Small specimens have no longitudinal sensilla on Fl_4 and the length/width ratio of Fl_2 can be small compared to that of large specimens. Although only two host species are known, other host eggs of varying sizes are likely parasitized as well, which would account for the size variation. Some of the numerous other insects, especially Coleoptera, and Diptera, and other Hemiptera associated with *Lemna* (Scotland 1939, 1940) are likely hosts and perhaps a variety of Odonata (Zygoptera) are as well. A complex of species may be involved, all collected near or on water and on different hosts. Because the kind of flagellomere variation that occurs among these specimens is similar to that found in *A. pallipes* (large specimens have longitudinal sensilla on Fl_4, small ones do not, and somewhat intermediate conditions occur), I prefer to treat them all as one species until crossing experiments with specimens reared from different hosts show otherwise.

Distribution. Canada (MB, ON, QC), USA (CA, MD, NY, VT). Probably widespread in the Nearctic region wherever water and host eggs occur. Specimens examined were mostly collected near or on water using yellow pan traps placed at the water's edge or on rocks emerging from the water. Specimens with narrow wings that might be referrable to *A. gerrisophaga* were seen from Hawaii (2♀ ♀, UCRC) and the Northwest Territories (1♀, UCRC). More material (for slide mounting) is needed from these areas to determine their identities more reliably.

Material examined. 24♀ ♀ and 1♂ (15 on slides). **CANADA. Manitoba:** 2 mi. E. Elma on hwy. 11, 31.vii.2000. M. Iranpour, pond (2 ♀ ♀, CNCI); hwy. 12, Piney, 11.viii.2000, M. Iranpour, ditch (3♀ ♀, CNCI). **Ontario:** Carlsbad Springs, Mer Bleue bog, 12.vii.1980, 14-23.vi.1982, A. Davies (3♀ ♀, CNCI); 2 km SE. Innisville, 45°13'N 76°115'E, 5-12 ♀ 12-19.vi.1991, L. Masner, J. Denis, aquatic pan trap (2♀ ♀, CNCI); London, 24-27.vii.1981, A. Tomlin (1♀, CNCI); Nepean, Jock River at hwy. 16, 9-10.viii ♀ 23-24.ix.1999, L. Masner, YPT on boulders in river (2♀ ♀, CNCI); Oxford Mills, 22-29.vi, 36.vii, 13-20.vii, 27.vii, 24-31.viii, 21-28.ix, 28.ix-12.x.1973, L. Masner (38♀ ♀, 3♂ ♂, CNCI); St. Lawrence Is. Nat. Park, Genadier I., 11.vi.1975, in marsh under *Salix* (1♀, CNCI); **Quebec.** Bouchette area, Gatineau River, 18-19.ix.1999 (2♀ ♀, CNCI); Ancienne Lorette, aviation field [near Quebec City], coll. 13.ix.1973, em. 19.ix.1973, and coll. 1.x.1971, em. 4, 10 ♀ 22.x.1971, ex. *Lestes disjunctus* in *Eleocharis obtusa*, J.-P. Laplante (5♀ ♀, 2♂ ♂, CNCI); Gatineau Park, sweeping along parkway, 13.vi.1980, L.& R. Masner (1♀, CNCI); Lac Roddick outlet, 6 km N. Bouchette, 9-10.ix.2000, L. Masner (2♀ ♀, CNCI); Ste. Foy, host egg coll. 7.ix.1971, em. 10.ix.1971, ex. *Lestes disjunctus* in *Eleocharis obtusa*, J.-P. Laplante (1♀, CNCI); **USA. Maryland.** Prince Georges Co.: Laurel,

Patuxent Wildlife Research Center, 6-13.vii.1979, Malaise trap on powerline cut, M. Schauff (3♀♀, USNM). **New York.** Tompkins Co., Ithaca, viii.1938 ♀ summer, 1939 M.B. Scotland, on *Lemna* (5♀♀, 1♂, USNM). **Vermont.** Rutland Co., Danby, 3 mi. E. Green Mtn. National Forest, 31.vii.1979, M. Schauff & E. Grissell (3♀♀, USNM).

Hosts and Biology. The only host records are for the holotype from an egg of *Gerris* sp. (Gerridae), and a series from *Lestes* (Lestidae) eggs in *Eleocharis obtusa*.

Comments. The forewings of the holotype are not positioned flat, hence appear to be slightly narrower than they actually are, which explains the unusually high length/width ratio for the holotype (Table I). The paratype, collected on a window pane, is not conspecific with the holotype and is therefore excluded from the redescription given above.

Some specimens (USNM) identified as *A. pullicrurus* by A. Gahan and H. Dozier fit *A. gerrisophaga* better. These include the series reared at Ithaca from *Lemna* by M. Scotland and a male from Muncie, IL, collected by Dozier. The Dozier male is much larger than the single male reared by Scotland and the thoracic setae are relatively shorter (the ocellar setae are not clearly visible). Otherwise it seems to fit *A. gerrisophaga* better than *A. pullicrurus* because FWL/FWW is 8.83, closer to the ratio for the male reared from an unknown host in *Lemna*, which is 9.38.

Anaphes listronoti Huber

(Figs. 8, 23, 42)

Anaphes n.sp.; Boivin 1994: 233 (cold hardiness).

Anaphes listronoti (nomen nudum); Cormier *et al.*, 1996: 1376 (seasonal ecology, distribution);

Anaphes listronoti Huber *et al.*, 1997: 963 (original description); van Baaren *et al.*, 1997: 189 (description of first instar larva); Vigneault *et al.*, 1997: 548 (olfactometry); van Baaren and Boivin, 1998a: 525 (mention); Cormier *et al.*, 1998: 1596 (sexual pheromone emission); van Baaren and Boivin, 1998b: 9 (host discrimmination behavior); van Baaren *et al.*, 1999: 1 (antennal sensilla); Boivin and van Baaren, 2000: 471 (larval agression and mobility); Brodeur and Boivin, 2004:34 (mention).

Since Huber *et al.* (1997) described *A. listronoti*, several additional papers on this species were published, making it biologically one of the best known mymarids. These papers are listed above, together with a few that were incompletely cited or missed previously.

Type material. HOLOTYPE ♀ (CNCI), examined (see Huber *et al.* 1997), from CANADA: Quebec, Ste. Clotilde.

Diagnosis. Occipital suture straight (as in Fig. 30), ovipositor extending well under gaster (Fig. 42), forewing (Fig. 23) with posterior margin narrowly brown at least distally, Fl_2 (Fig. 8) with 1 or 2 longitudinal sensilla, gregarious in eggs of *Listronotus oregonensis*. Morphologically, *A. listronoti* is apparently indistinguishable from *A. sordidatus*. Biologically, the species can be distinguished because *A. sordidatus* is a solitary parasitoid in *Tyloderma foveolatum* and will not cross with *A. sordidatus* in the laboratory.

Statistics of the antennal segments are given in Table XVIII to complement the description in Huber *et al.* (1997) and for comparison with the antennal descriptions of the other species redescribed here. Since the original description, two new morphological features have been found to separate *A. listronoti* from *A. victus*. *Anaphes listronoti* females have 6-9 sensilla chaetica type 4 on the clava compared with 10-12 on the clava of *A. victus* (van Baaren *et al.* 1999). Unfortunately, these are not clearly visible on dried or slide-mounted specimens so the feature

cannot be used for routine determination. The first instar mymariform larvae of *A. listronoti* show no visible segmentation in contrast to those of *A. victus*, which are clearly segmented (van Baaren *et al.*1997).

Distribution. Canada (ON, QC), ?USA (MI).

Anaphes longiclava (Doutt)

(Figs. 9, 24, 43)

Anaphoidea longiclava Doutt, 1949: 158 (original description).

Patasson longiclava; Burks, 1958: 63 (catalog); Peck, 1963: 34 (catalog); Burks, 1979: 1030 (catalog).

Anaphes longiclava; Schauff, 1984b: 216 (comparison with *diana*).

Anaphes longiclavus; Huber, 1992: 74 (list, incorrect species spelling).

Type material. HOLOTYPE ♀ (EMEC), examined. On slide labelled: 1. "by sweeping native vegetation Morgan Hill, Calif. July 2, 1947 R.L. Doutt". 2. "*Anaphoidea longiclava* Doutt ♀ Type" (red label). The type is in rather poor condition with body mounted laterally, head detached and mounted vertically, left eye torn away from vertex which, together with occiput, is slightly torn, left antenna and right antenna beyond pedicel broken off and positioned elsewhere on slide, and both forewings, right hind wing and left foreleg detached and positioned elsewhere on slide. Its measurements are given in Table I. PARATYPE ♀ (EMEC) labelled 1. "by sweeping Salix Rio Nido, Calif. May 28, 1947 R.L. Doutt". 2."*Anaphoidea longiclava* Doutt ♀ Paratype" (yellow label). The head with one antenna and body were remounted under two 6-mm coverships on the original slide after clearing in KOH.

Diagnosis. Occipital suture straight (as in Fig. 30), ovipositor longer than metatibia and extending under mesosoma to base of mesocoxae (Fig. 43), Fl_2 without longitudinal sensilla (Fig. 9), hind leg with tarsomere 1 slightly shorter than tarsomere 2, FWL/FWW at most 5.4 (4.6 in holotype); body length 413.

The small body size and relatively broader forewing distinguish *A. longiclava* from *A. luna* and *A. diana*. *Anaphes longiclava* is the smallest described native Nearctic species of the genus, only slightly larger than the introduced *A. diana* and equal to exceptionally small specimens of *A. luna*.

Description. Female. *Colour.* (From uncleared type slides). Brown with antennae and legs, especially tarsi lighter. The holotype is generally lighter in colour than the paratype. Forewing (Fig. 24) with a narrow brown margin in half of posterior margin.

Body length. 413µm (holotype).

Head. Width 188 (n=1). Occipital suture straight (as in Fig. 30). Ocellar setae as long as about half diameter of anterior ocellus.

Antenna. Scape with ventral margin moderately rounded, with extremely faint oblique striations on inner surface. Fl_3, Fl_5 and Fl_6 each with 2 longitudinal sensilla, Fl_4 with 1 longitudinal sensillum (Fig. 9). Fl_1 with base slightly narrower than apex. Measurement are given in Table XIX.

Mesosoma. Pronotum and mesonotum with moderately long setae.

Wings. Forewing length 533 (n=1), width 115, FWL/FWW 4.63, LMC 149, their length about 1.3 times forewing width; marginal space 97, medial space triangular, cubital line of setae closest to posterior margin near the retinacular seta and further away distally, with a gap of about one setal length between the cubital line and posterior margin of wing. Hind wing length 500 (n=1), width 23, with 3 microtrichia medially on blade in apical half, LMC 178.

Legs. Foretibia with 8 sensilla chaetica. Hind tarsomere 1 slightly shorter than tarsomere 2 (Table I).

Metasoma. Ovipositor length (n=1) 1.14 times length of hind tibia, extending slightly under mesosoma to level of base of mesocoxa (Fig. 43).

Male. Unknown.

Distribution. USA (CA).

Material Examined. Only the two type specimens were examined.

Hosts and Biology. Unknown. The holotype was collected by sweeping native vegetation and the single paratype by sweeping *Salix.*

Comments. The wing proportions of the holotype and paratype of *A. longiclava* are quite different (FWL/FWW 4.63 and 5.32, respectively) and I am not sure if they belong to the same species. In the absence of a series of specimens variation cannot be adequately assessed.

Specimens of an *Anaphes* sp. (in CNCI) similar in body length to *A. longiclava* were reared from *Tanysphyrus lemnae* (Fabricius) (Curculionidae) in Florida. They have a body length of about 310μm, a small Fl_4 without longitudinal sensilla, and the ovipositor up to 1.7 times as long as the hind tibia. They may be *A. longiclava* but until specimens are reared from *T. lemnae* from California and more specimens are reared from this host in Florida and elsewhere to determine variation and geographic distribution more completely I hesitate to name the Florida specimens as *A. longiclava.* Otherwise, a host would now be known for *A. longiclava.*

Anaphes luna (Girault)

(Figs. 10, 25, 34, 44)

Anaphoidea luna Girault, 1914a: 87 (nomen nudum, host); Girault, 1914b: 109 (original description); Silvestri, 1915: 80 (egg morphology and development); [Girault,] 1916: 40 (host); Chamberlin, 1924a: 3 (original releases in North America); Chamberlin, 1924b: 627 (oviposition, distribution); Howard, 1927: 14 (further importations from Europe); Girault, 1929: 12 (synonymy under *conotracheli*); Essig and Michelbacher, 1933: 69 (hosts, introduction into USA); Kaufmann, 1939: 421 (German record); Clausen, 1940: 102 (host, egg parasitism); Kaufmann, 1941a: 110 (hosts); Kaufmann, 1941b: 83 (host); Hamlin *et al.*, 1949: 58 (liberation and first recovery); Doutt, 1949: 160 (citation of previous synonym); Clausen, 1956: 116 (importation, parasitism rate); Tooke, 1955: 103 (1 larval instar according to Silvestri); Baccetti, 1957: 110 (hosts, oviposition); Baccetti, 1958: 197 (host); Thompson, 1958: 569 (host); Nasr, 1998: 17 (life cycle abstract).

Anaphes luna; Gould, 1986 (biology); Huber, 1986: 197 (biocontrol mention); Pagliano and Navone, 1995: 35 (Italian checklist); Radcliffe and Flanders, 1998: 233 (parasitism rate, distribution).

Anaphes (*Patasson*) *luna*; Viggiani, 1994: 474 (male genitalia).

Patasson luna; Peck, 1963: 32 (?separate from *conotracheli*); Shaw and Ziener, 1964: 138 (reared in western Massachusetts); Shaw and Miller, 1965: 1131 (reared in western Massachussetts); Streams and Fuester, 1966: 331 (abundance, survival); Burks, 1967: 214 (removal from synonymy under *conotracheli*); Brunson and Coles, 1968: 6 (percent parasitism, release in Utah); Petty, 1968: 129 (first rearing in Illinois); Mailloux and Pillon, 1970: 607 (recovery in Quebec); Miller, 1970: 440 (mention); Niemczyk and Flessel, 1970: 247 (parasitism rate); Miller and Guppy, 1972: 45 (rearing record: Harrow, ON); Ellis, 1973: 1060 (parasitism rate); Aeschlimann, 1975: 407 (biological control

mention); Dysart and Day, 1976: 2 (introduction history, distribution, parasitism rate); Harcourt *et al.*, 1977: 1522 (parasitism rate); Clausen, 1978: 267 (importation, release, life cycle); Hopkins, 1978b: 5 (summary of recoveries by state, parasitism rate); Burks, 1979: 1030 (catalog); Schaber, 1981: 169 (Alberta record); Collins and Grafius, 1983: 1 (host); Day, 1983: 41 (biology); Hogg and Kingsley, 1983: 54 (parasitism rate); Bryan *et al.*, 1993: 26, 35 (distribution map, summary of establishment).

Mymar luna; Poinar and Gyrisco, 1963: 534 (parasite emergence from egg); El M'Sadda, 1967: 13 (parasitism rate); Niemczyk and Flessel, 1970: 247 (parasitism rate).

Type material. LECTOTYPE ♀ (USNM), here designated. On slide labelled: 1."*Anaphoidea luna* Gir. Types and Paratypes Type No. 15452 U.S.N.M. [red label]". 2."6655 Mymarid Parasite of *Phytonomus* (from shipment from Italy by Fiske) Salt Lake City Apr. 8 1911. T. H. Parks". The lectotype is uncleared and mounted in lateral view at the edge of the coverslip and ringed by a faint blue line. The head is collapsed but otherwise in good condition. Measurements are given in Table I. *A lectotype* is designated to fix the name by eliminating the possibility of confusion with similar species and because the original introduction of *A. luna* probably included more than one species. PARALECTOTYPES. Two females and three males on same slide as lectotype, all uncleared, intact, and mounted in lateral view near the edge of the coverslip.

Diagnosis. Fl_2 without longitudinal sensilla. FWL/FWW less than 6.5. Ovipositor length 285 (252-335, n=6), extending under mesosoma only to about apex of mesocoxa. Body length about 413-603. The only described Nearctic species that has this combination of features is *A. longiclava*, a much smaller species that could only be confused with very small specimens of *A. luna*.

This species is diagnosed (and redescribed) only from the specimens introduced in 1911 to avoid the problem of antennal variation (discussed below). Even so, it is difficult to diagnose *A. luna* because it has no remarkable features and seems to be quite variable. Specimens introduced from Europe in 1926 and those reared from *Hypera postica* in North America after that date may or may not be the same and are discussed below.

Description. Female. *Colour* (from uncleared slides). Dark brown with antennae and legs beyond coxae lighter. Forewing (Fig. 25) narrowly brown along posterior margin but lighter than along anterior margin. Girault (1914b) described the species as "black, the scape, pedicel and proximal three tarsal joints dusky lemon yellow, the trochanters and knees [i.e., junction of femora and tibiae] pallid . . . cephalic tibiae lighter".

Body length. 501 (≈413-603, n=10, from slide-mounted specimens). Body length is based on the original series from Portici and Salt Lake City (collected in 1911).

Head. Width 203 (n=1). Occipital suture straight (as in Fig. 30). Ocellar setae a little shorter than diameter of anterior ocellus.

Antenna. Scape with inner surface with very faint oblique striations. For specimens from original 1911 introduction, Fl_3, Fl_5 and Fl_6 each with 2 longitudinal sensilla (Fig. 10); Fl_4 with 0-2 longitudinal sensilla. For specimens collected in North America since 1926 introductions, Fl_2, Fl_3, Fl_5 and Fl_6 each with 2 longitudinal sensilla (Fig. 10); Fl_4 usually with 2 longitudinal sensilla on each antenna, rarely with 2 and 1, 1 and 1, 1 and 0, or even 0 and 0 longitudinal sensilla. Measurements are given in Table XX (specimens from original introduction into North America) and Table XXI (specimens reared from field-collected *Hypera postica* in North America).

Mesosoma. Pronotum and mesonotum with short, inconspicuous setae.
Wings. Forewing length 652 (536-780, n=7), width 102 (85-137), FWL/FWW 6.40 (5.70-7.13), LMC 141 (123-161), their length about 1.4 times forewing width; marginal space 100 (72-124), medial space triangular, cubital line of setae uniformly close to posterior margin with a gap of about half a setal length between the cubital line and posterior margin of wing. Hind wing length 623 (531-750, n=7), width 28 (24-34), with 0-12 microtrichia medially on blade in apical half, LMC 115 (105-130).
Legs. Foretibia with 9-11 sensilla chaetica. Hind tarsomere 1 0.92 (0.86-0.98, n=2) times as long as tarsomere 2 (Table I).
Metasoma. Ovipositor length 285 (252-335, n=6), 1.38 (1.25-1.50) times as long as hind tibia, and extending under mesosoma at least to apex of mesocoxa or as far forward as middle of forecoxa (Fig. 44).
Male. Total length of flagellum (n=3) 206 (175-232). Length of antennal segments (n=2 to 5): scape 101 (100-103), pedicel 43 (41-44), Fl_1 5 (4-6), Fl_2 61 (56-65), Fl_3 65 (56-76), Fl_4 64 (47-69), Fl_5 65 (49-72), Fl_6 64 (55-72), Fl_7 63 (53-68), Fl_8 64 (51-71), Fl_9 64 (50-71), Fl_{10} 61 (50-68), Fl_{11} 63 (55-67). Fl_6 length/width ratio averaging 3.12 (2.69-3.58), with 4 (?5) longitudinal sensilla.
Variation. *Anaphes luna* is either a single very variable species or a complex of species. If it is a complex, many of the papers citing the name *luna* may not actually apply to *A. luna* (as described above, based on the type specimens). For example, vouchers of *A. luna* from the Ph.D. study by Gould (1986) may represent a different species. The Gould specimens differ from the type series in that Fl_2 bears 1 or 2 longitudinal sensilla on each funicle, as in *A. victus*, *A. sordidatus* and *A. listronoti*. Alternately, *A. luna* may simply be a very variable species, especially in the number and position of longitudinal sensilla on Fl_2 and Fl_4. Evidence for this is provided by specimens examined from material collected since 1958 in the northeastern US and Canada. Among these, some specimens also had 2 longitudinal sensilla on Fl_2 but every combination was found at least once, i.e. 2/1, 2/0, 1/1, 1/0, 0/0. Similarly, most specimens had 2 longitudinal sensilla on Fl_4 of each antenna but the various combinations (except 2/0) were found in at least one individual. Such variation may occur at the same place and time. A slide with five females and a male reared on 19.v.1973 at Ithaca, NY, shows considerable variation in antennal sensilla, with Fl_2 bearing 0/0, 1/0, or 1/2 longitudinal sensilla and Fl_4 bearing 0/1, 1/1, or 2/2 longitudinal sensilla. Specimens reared from alfalfa in Europe also show such variation, e.g., two slides of *A. luna* bearing six uncleared females from Arles, France, 6.i.1966 and ii.1966, alfalfa stems, F. Gruber (USNM). Two of the specimens have Fl_2 bearing 2/1 longitudinal sensilla, two have 0/0 longitudinal sensilla and two have 1/0 longitudinal sensilla. All but one of the specimens collected in February have 2/2 longitudinal sensilla of Fl_4 and the one collected on 6.i has 2/1 longitudinal sensilla. The specimens were not reared from known host eggs so the possibility exists that the six specimens emerged from different hosts in the alfalfa stems, which may account for the differences in antennal morphology. However, it is more likely that all the specimens emerged from alfalfa weevil eggs.
Crossing experiments need to be made between *A. luna* reared from alfalfa weevil and *A. victus* and *A. listronoti* reared from carrot weevil and *A. sordidatus* reared from *Tyloderma foveolatum* to see if they are conspecific or if they are biologically distinct. Possibly, one of the species (probably *A. victus*, which has a similar ovipositor length and is solitary) described by Huber *et al.* (1997) is a synonym of *A. luna*. It would also be interesting to cross *A. luna* reared from

H. postica with specimens reared from *H. eximia* on *Rumex* to confirm that they are the same species. I am not completely certain that they are.

Distribution. Europe, Canada (AB, ON, PE), USA (DE, IL, IN, MD, MI, MO, NJ, NY, UT, WV, WI). In 1928, when *A. fuscipennis* (as *A. pratensis*) was shipped from Utah to Indiana the shipment may have included some *A. luna*. Since then, *A. luna* has apparently become widely distributed in the northeast and north central USA (Radcliffe and Flanders 1998). Dysart and Day (1976) provided a detailed map of county localities. Bryan *et al.* (1993) stated that *A. luna* had not been redistributed but that it was well established in the USA and Canada.

Material examined. 133 ♀♀ and 50 ♂♂ (142 on slides) in USNM unless otherwise indicated. All *crassicornis*-group specimens reared from *Hypera postica* in North America are included here though possible they represent a complex of species, as discussed above. **CANADA. Alberta.** Lethbridge, 10.v.1978, B.D. Schaber (1♀, CNCI). **Ontario.** Ottawa, 22.vi.1970 (1♂, CNCI). **Prince Edward Island.** South Bay, 22.vii.1971 (1♀, 2♂, CNCI). **USA. Delaware.** New Castle Co.: New Castle, 20.ii.1961, A.H. Mason (1♀). **Illinois.** Crawford Co.: Trimble, 28.xii.1967, J. deWitt (1♀, 1♂); De Kalb Co.: De Kalb, vii.1968, J.B. Litsinger (7♀, 2♂); Mason Co.: near Havana, 4.vi.1974, D. Oldfield, ex. *Bathyplectes curculionis* (1♀, 2♂). **Indiana.** LaGrange Co.: Howe, 23.iv.1981, Chmiel (2♀); Tippecanoe Co.: West Lafayette, Purdue University, 15.x.1967, culture, R.C. Anderson (4♀, 3♂). **Maryland.** Beltsville, 11.vi.1962, J. Huggens (4♀, 1♂). **Michigan.** Ingham Co.: near East Lansing, 7.vii.1970, R.A. Casagrande (8♀, 2♂). Missouri. Cooper Co.: Bel Air, 4.v.2000, ex. *Hypera eximia* on pale dock, B. Puttler (3♀, 1♂, CNCI). New Jersey. Warren Co.: Hainsburg, spring 1963, D.R. Barnes (4♀, 1♂). **New York.** Dutchess Co.: Fishkill, 19.v. and vi.1959, S. Poinar (6♀, 1♂). Tompkins.: Ithaca, 19.v.1973, R. van Driesch (5♀, 1♂); Myers, 9.vii.1958, G. Poinar (1♀, 1♂). **Utah.** Cache Co.: Logan, vii.1972, D.W. Davis (8♀, 1♂); Salt Lake Co.: Salt Lake City, 3.iv.1911, from Portici, Italy, W.J. Fiske (Wesbster No. 6655) (3♀, 1♂), 6.iii.1911, hatching from *Phytonomus* [=*Hypera*] eggs, T.H. Parks (2♀, 1♂, 1 unknown sex); same locality except no date, T.H. Parks (1♀, 1♂); same locality, 12.vi.1911, T.H. Parks, on *Phytonomus* reared through Utah eggs (7♀, 4♂, 1 adult in egg). **West Virginia.** Preston Co.: 21.xi.1968, C.K. Dorsay (10♀, 2♂), iii.1969, J.E. Weaver (23♀, 8♂). **Wisconsin.** Columbia Co.: Arlington, 19.v.1969, D. Litsinger (9♀, 1♂); Dane Co.: Madison, ex. lab. culture, spring, 1985, W. Gould (27♀, 10♂, CNCI); Green Co.: Jefferson Township, 15.v.1980, D.B. Hogg (5♀, ?7♂).

Hosts and Biology. Curculionidae are the only confirmed hosts and include in North America the alfalfa weevil, *Hypera postica* (Gyllenhal) on alfalfa and *H. eximia* (LeConte) on pale dock (*Rumex ?orbiculatus* Gray), and in Europe and North Africa the Egyptian alfalfa weevil, *H. brunneipennis* (Boheman), *H. trilineata* Marsham, possibly *H. punctata* (Fabricius), *H. variabilis* Herbst (Kaufmann 1941a), *H. zoilus* Scopoli (Baccetti 1957), and *Hypera* [as *Donus*] *crinitus* (Boheman). Baccetti (1958) was uncertain if the species he reared from *H. crinitus* was *A. luna*. One of the slides, bearing the number 6655 with specimens reared in Salt Lake City has host eggs labelled as *Phytonomus* [= *Hypera*] *murinus* F., which does not occur in N. America. The specimens from near Havana, IL, supposedly reared from *Bathyplectes curculionis* (Thomson) (Ichneumonidae) clearly are incorrectly associated with this host. They must have been reared from eggs of *Hypera postica*. Three slides of *Anaphes*, labelled s.l. # 3007, reared from *Hypera punctata* by Chamberlin, do not appear to be *A. luna*, which places doubt on Kaufmann's (1941a, b) host record from Europe.

Dysart and Day (1976) and Clausen (1978) summarized the biology of *A. luna*. Clausen (1940)

noted that in fresh alfalfa only eggs near the oviposition puncture can be reached for parasitism, but the female wasp can enter dry stems so the entire egg mass is then susceptible to parasitism. At least two generations per year occur. Females lay one or two eggs inside a host egg and egg parasitism seldom exceeds 5% both in Europe (e.g., El M'Sadda 1967) and North America (Radcliffe and Flanders 1998), though Brunson and Coles (1968) reported 10% parasitism. Nasr (1998) provided an abstract of the life cycle of *A. luna* from *H. brunneipennis* in Egypt. A series of slides each labelled "ex. egg *Hypera postica*" (Jefferson Township, Green Co., WI) and each with either one female or one male specimen of *A. luna* seems to confirm Clausen's (1978) statement that the species is solitary. But six slides each labelled "ex. alfalfa weevil egg" (Preston Co., WV), have five specimens per slide, and one has six specimens. Each of these slides has one or two males and the remainder are females. The species (if it is indeed the same species – I cannot tell, based on morphology) may therefore sometimes be gregarious (or else two species are involved).

Introductions into North America. The original releases of at least 1740 adults of *A. luna* from Italy were made near Salt Lake City from 1911-13 but the releases failed to become established (Chamberlin 1924a). New importations and releases were made from 1925-1928 (Brunson and Coles 1968) and included both *A. luna* and *A. fuscipennis* (as *A. pratensis*). According to Hamlin *et al.* (1949), the two species were released together because they could not be distinguished when alive. The first recovery was in 1926, but of *A. fuscipennis* not *A. luna*, which apparently failed to become established. In addition to the type slide, five slides of specimens in the USNM with the same catalog number (Webster No. 6655) as the type slide were examined. Four are dated 1911 (3 April to 12 June, depending on slide) and one has no date. The specimens on these slides are evidently from the original introduction of *A. luna* into North America but do not form part of the type series. They are important because they contain three species, presumably all from material obtained originally from Portici, Italy. The undated slide bears one female of *A. fuscipennis* as well as a male and female of *A. luna*. The slide dated 3 April bears two females and two males of *A. luna*, and one female of a small specimen with ovipositor extending almost to the head and Fl_1-Fl_3 without longitudinal sensilla. It is very poorly oriented and its identity is unknown but it is very likely not a specimen of *A. luna*. Another set of releases was made from 1925-1928, again from material from Italy. Five slides of voucher specimens (USNM) from the 1925-1928 introductions, labelled S.L. Sta. [St. Louis Station] #3007 and dated either 14 or 24 May, 1926, were examined. Three of these slides bear specimens reared from *Hypera punctata*. These appear not to be *A. luna* but key instead to a species close to *A. leptoceras* Debauche in Debauche (1948). The remaining two slides, labelled as "ex.stems alfalfa" contain *A. luna*. In 1933-34, *A. luna* from France was released in California. According to Dysart and Day (1976), *A. luna* was apparently mixed with *A. fuscipennis* (as *A. pratensis*) in all these introductions, so its early spread cannot be accurately assessed. If the specimens on these two sets of slides are representative of what was released in North America in 1911-1913 and 1925-1928 then at least two more species besides *A. fuscipennis* and *A. luna* may have become established on alfalfa weevil in North America. If so, that may account for the considerable variation seen in *A. luna* (see Variation, above).

Fischer *et al.* (1961), van den Bosch (1964), Clancy (1969), and Clausen (1978) refer to a *Patasson* sp. reared from *Hypera brunneipennis* (Boheman) in Iran and Egypt that was released in California but apparently, and from a taxonomic viewpoint, luckily, did not become established.

Perhaps the species they referred to is the same as *A. luna* but I have not seen voucher specimens to verify this. In retrospect, it is impossible to know exactly how many species ultimately became established in North America from shipments originating from the Old World.

Biological control. Many of the numerous references on *A. luna* mention this species in connection with biological control of the alfalfa weevil. Although *A. luna* had a relatively small role in the successful control of alfalfa weevil in northeastern North America, it nevertheless contributed, and still contributes, to the overall reduction in damage by this pest. Continued search for races of *A. luna*, or very similar species of *Anaphes* that are more adapted to the drier conditions of the southern USA where alfalfa weevil or Egyptian alfalfa weevil are still important pests, may result in further introductions of *Anaphes* species. *Anaphes luna* has been recorded from Egypt (Nasr 1998) and Sicily (Pagliano and Navone 1995), both Mediterranean areas, so a suitable race or species for successful introduction into southern USA must exist. If further introductions of *Anaphes* spp. are made, it is essential, from a taxonomic viewpoint, that sufficient voucher specimens (at least 10 males and 10 females, killed directly in at least 70% ethanol) be preserved in major institutions for species confirmation. The doubt surrounding the identity of *A. luna* because of the release of a mixture of two or more species during the first half of the 1900's, poor identifications, and too few, poor quality, voucher specimens should not be repeated.

Comments. Girault (1929) incorrectly synonymized *A. luna* under *A. conotracheli*. Doutt (1949) accepted Girault's (1929) synonymy and therefore did not include *A. luna* as a separate species in his key to North American species. Poinar and Gyrisco (1963), El M'Sadda (1967) and Collins and Grafius (1983) also mistakenly treated the two names as synonyms, presumably following Girault. Peck (1951) classified *A. luna* under *A. conotracheli* but then (Peck 1963) noted that it should perhaps be regarded as a distinct species. Burks (1967) correctly removed it from synonymy after examining the types.

At least one other species of *Anaphes* (belonging to the *fuscipennis* species group) was reared from alfalfa weevil (Indiana, Harrison Co. 20.ii.1967, R.C. Anderson, 1♀ and 1♂ on slide, USNM). This species appears to be undescribed and is likely to be found normally on a host other than alfalfa weevil or it may be rare.

Anaphes pallipes (Ashmead)

(Figs. 12, 26, 31, 45)

Alaptus pallipes Ashmead, 1887: 193 (original description); Girault, 1908: 186 (description quoted); Girault, 1910: 243 (removal from *Alaptus*).

Anaphes pallipes; Girault, 1911c: 186 (mention); Girault, 1911e: 278 (redescription); Girault, 1929: 13 (key); Burks, 1979: 1029 (catalog); Huber and Rajakulendran, 1988: 899 (correction of Girault misidentification).

Mymar pallipes; Peck, 1951: 416 (catalog); Peck, 1963: 40 (catalog).

Anaphoidea conotracheli; Porter and Alden, 1921: 62 (emergence, parasitism rate, host), Porter, 1928: 28 (parasitism rate). Misidentification.

Anaphes conotracheli; Porter, 1922: 165 (percent parasitism); Schauff, 1984a: 48 (host). Misidentification.

Type material. HOLOTYPE ♀ (USNM), examined. Originally mounted in balsam under one coverslip on slide labelled: 1. "*Alaptus* 13807 [pencil] *pallipes* Ashm. Jacksonville, Fla Type". 2."

(Alaptus) *Anaphes pallipes* Ashm. ♀ Type No. 13807 U.S.N.M. [red label]". The holotype was in poor condition, uncleared and mounted laterally with face head up (Fig.45). One forewing was detached and obliquely positioned at some distance from body. The remaining wings, clava of left antenna, Fl_6 and clava of right antenna, tarsus of right foreleg and left middle leg, trochanter of right middle leg, and right hind leg were missing. I successfully removed the specimen from the original slide, cleared it in KOH and remounted it under two coverslips so that critical diagnostic features could be observed. Measurements are given in Table I.

Ashmead (1887) miscounted the antennal segments on the holotype, evidently not realizing that the clava from each antenna was missing. He mistook the last flagellar segment for a clava and therefore counted only five flagellomeres. This explains why he placed the species in *Alaptus*. Because of his mistake his description of the antenna is inaccurate and misleading.

Diagnosis. Occipital suture short and oblique, pointing ventromedially towards occipital foramen (Fig. 31). Inner surface of scape and pedicel with distinct, oblique cross striations. Flagellum with longitudinal sensilla on Fl_3, Fl_5 and Fl_6 but none on Fl_4, which is consequently shorter and narrower (Fig. 45). Two specimens from Zilker Park have only 1 (0?) longitutinal sensillum on Fl_3 and Fl_6 of at least one flagellum (Fig. 12). The only described Nearctic species that could be confused with *A. pallipes* is *A. conotracheli*. Specimens of *A. pallipes* are smaller than *A. conotracheli* in all measurements, probably due to the smaller host from which they have been reared. As mentioned under *A. conotracheli*, the species are probably the same. Because of the considerable literature on *A. conotracheli* I do not synonymize it under *A. pallipes* until crossing experiments or molecular data can confirm their conspecificity.

Description. Female. *Colour* (from critical point dried specimens). Body brown; legs almost white except for coxae, femora medially, and tarsomere 4 which are light brown. Forewing (Fig. 26) with posterior margin clear to apex of wing or at least distinctly lighter brown than anterior margin, except for a short brown section subapically.

Body length. 433µm (396-515, n=9, from critical point dried specimens).

Head. Width 180 (167-199, n=8). Occipital suture short, angled inwards towards dorsal margin of occipital foramen (Fig. 31).

Antenna. Inner surface of scape with distinct cross striations almost at right angles to length of scape. Fl_5, Fl_6 and usually Fl_3 each with 2 longitudinal sensilla (Fig. 12, 45). Measurements given in Table XXII.

Mesosoma. Pronotum and mesonotum with short, inconspicuous setae.

Wings. Forewing length 508 (442-559, n=10), width 106 (88-128), FWL/FWW 4.71 (4.34-5.27), LMC 120 (90-128); marginal space 88 (71-104), medial space triangular, cubital line of setae closest to posterior margin just beyond retinaculum, then diverging so posterior row of setae about one setal length from posterior margin. Hind wing length 496 (428-552, n=11), 23 (20-27), without microtrichia (one specimen with 1 microtrichia) medially on blade in apical half, LMC 92 (85-102).

Legs. Foretibia with 7 or 8 sensilla chaetica. Hind tarsomere 1 0.71 times length of tarsomere 2 (0.67-0.75, n=3).

Metasoma. Ovipositor length 307 (269-347, n=9), 2.0 (1.9-2.1) times as long as hind tibia, extending under mesosoma at least as far as apex of forecoxa (Fig. 45).

Male. Total length of flagellum 576 (546-609, n=4). Length of antennal segments (n=2 to 6):

scape 72 (69-75), pedicel 39 (38-43), Fl_1 6 (6-8), Fl_2 52 (46-56), Fl_3 55 (48-60), Fl_4 53 (45-60), Fl_5 55 (51-60), Fl_6 56 (47-61), Fl_7 56 (46-61), Fl_8 58 (55-59), Fl_9 58 (55-59), Fl_{10} 59 (57-60), Fl_{11} 61 (56-63). Fl_5 length/width ratio averaging 2.5 (2.4-2.8), with 5 longitudinal sensilla.

Distribution. Canada (ON), USA (CT, FL, IL, ND, TX).

Material examined. 21♀♀ and 15♂♂ (20 on slides). **CANADA. Ontario.** Ottawa, 12.viii.2003, J.R. Vockeroth, in bus shelter (1♀, CNCI). **USA. Connecticut.** New Haven Co.: Wallingford, viii.1920, Porter and Allen (2♀ ♀, 2♂ ♂, slides Q. no.1611). **Illinois.** Cook Co.: Chicago, Clayton Smith Forest Preserve, 31.vii.1989, J.D. Pinto, sweeping (1♀, CNCI); Effingham Co.: SSW. Mason, 7.ix.1993, J.D. Pinto (1♂, CNCI). **North Dakota.** Cass Co.: 4 mi. N. & 4. mi. W. Casselton Vining's sunflower plot, 15, 20, 22 & 26.vii and 5 & 9.viii.1982, L.D. Charlet & T.A. Gross, ex. *Cylindrocopturus adspersus* on *Helianthus annuus* L. (9♀, 7♂, CNCI). **Texas.** Travis Co.: Austin, Zilker Park, 8.x.1983, J.B. Woolley (8♀, 5♂, CNCI).

Hosts and Biology. The specimens from *Cylindricopturus adspersus* mentioned by Schauff (1984a) as being *A. conotracheli* are treated here as *A. pallipes*. The specimens from Connecticut, determined as *A. conotracheli* by Gahan, were reared from *Rhagoletis pomonella* Walsh (Tephritidae) by Porter and Alden (1921). Porter (1922) and Porter (1928) reported up to 25% and 30% parasitism of *R. pomonella* at Wallingford, CT.

Comments. The homotype and plesiotype no. 44,225 (from Centralia, IL) that Girault (1911e: 279) designated and referred to as *A. pallipes* actually belongs to *Anaphes iole* of the *fuscipennis* species group (Huber and Rajakulendran 1988, Huber 1992). As pointed out by Underhill (1926: 17) the occurrence of *A. pallipes* reared from cages containing *Gnorimoschema operculella* Zeller is doubtful. No mymarids are reliably known to parasitize lepidopterous eggs so this reference to *A. pallipes* is almost certainly incorrect. *Anaphes pallipes* probably has a wide North American distribution, based on the little material seen so far. The host genera *Cylindrocopturus* and *Rhagoletis* are widespread and further rearings from any species in these genera may yield *A. pallipes*.

Anaphes pullicrurus (Girault)

(Figs. 13, 27, 46)

Anaphoidea pullicrura Girault, 1910: 252 (original description); Girault, 1911a: 216 (comparison with *diana*); Girault, 1911d: 187 (additional specimen); Girault, 1911e: 288 (mention); Girault, 1914b: 109 (comparison with *luna*); Frison, 1927: 227 (holotype data listed); Gahan, 1927: 32 (comparison with *calendrae*); Girault, 1929: 12 (key, synonymy under *conotracheli*); Doutt, 1949: 160 (previous synonymy under *conotracheli* cited); Poos, 1955: 559 (host record); Webb, 1980: 118 (holotype listed).

Patasson pullicrura; Peck, 1951: 415 (catalog); Peck, 1963: 34 (catalog); Burks, 1979: 1030 (catalog).

Anaphes pullicrurus; Huber 1992: 76 (list).

Type material. HOLOTYPE ♀ (INHS), examined. On slide labelled:1."No. 41686. *Anaphoidea pullicrura* Gir ♀ Centralia Illinois Type. Ag. 26 1909 xylol balsam. Girault s. 1485". 2. "TYPE ♀ *Anaphoidea pullicrura* Girault" [red label]. The specimen is uncleared, in fairly good condition, mounted laterally, with both hind wings, and Fl_6 + club of right antenna detatched and positioned away from the body, and tarsomeres 2-4 of the left hind leg missing. Holotype measurements are given in Table I. PARATYPE. The female collected on 30 August

was examined and appears to be conspecific with the holotype. It is on a slide that also bears a male of *A. ?iole*, a female of *Anagrus* sp., and a female of *Camptoptera pulla*. Girault described *A. pullicrurus* from four females "on the panes of a small window" at Centralia, IL, on 26 and 30 August and 5 September, 1909. Two slides bearing only part of the series from which Girault described the species were located. The paratype female collected on September 5 is lost (D. Webb, Illinois Natural History Survey, pers. comm.). The fourth paratype female is also apparently lost, unless it is the male of *A. ?iole*. It is unlikely, however, that Girault would have confused this female for a male.

Diagnosis. Forewing narrow (FWL/FWW 7.0-8.6), thoracic setae short, inconspicuous; funicular segments relatively short and broad. *Anaphes pullicrurus*, *A. gerrisophaga* and *A. cotei* all have relatively narrow forewings. *Anaphes pullicrurus* differs from *A. gerrisophaga* by its short, inconspicuous thoracic setae and a relatively wider forewing (long, distinct setae and narrower forewing in *A. gerrisophaga*) and from *A. cotei* by Fl_2 and the remaining funicular segments relatively shorter and broader (compare Tables XXIII and XV).

Description. Female. *Colour* (from uncleared, slide-mounted specimens). Body brown; legs lighter, uniformly brown except for base of femora at junction with trochanters. Forewing (Fig. 27) with posterior margin narrowly brown along its entire length. Girault (1910) described the colour in detail and his description is certainly more accurate, as it is based on at least one specimen that was not first slide mounted.

Body length. 460 (450-480, n=4).

Head. Width 167 (paratype) and 197 (specimen ex. *Chaetocnema denticulata*). Occipital suture straight (as in Fig. 30).

Antenna. Inner surface of scape not clearly visible on specimens examined. Fl_3 & Fl_6 each with 2 longitudinal sensilla (Fig. 13). Measurements given in Table XXIII

Mesosoma. Pronotum and mesonotum with short, inconspicuous setae.

Wings. Forewing length 612 (585-634, n=5), width 77 (72-86), FWL/FWW 8.03 (6.99-8.59), LMC 124 (115-135), their length about 1.6 times forewing length; marginal space 79 (74-86), medial space triangular, cubital line of setae closest to posterior margin near the retinacular seta and slightly further away distally, with a gap of about one setal length between the cubital line and posterior margin of wing. Hind wing length 570 (519-593, n=5), width 23 (20-25), with 0-4 microtrichia medially on blade in apical half, LMC 176 (173-203).

Legs. Foretibia with 8-10 sensilla chaetica. Hind tarsomere 1 0.91 (0.83-0.95, n=5) times as long as tarsomere 2.

Metasoma. Ovipositor length 296 (272-312, n=5), extending under mesosoma past base of mesocoxa (Fig. 46)

Male. Unknown. See comments below. A male identified as *A. pullicrura* collected by sweeping a creek bed in Muncie, IL has the same wing proportions as *A. pullicrura* but is much larger. It is discussed under *A. gerrisophaga*.

Distribution. USA (IL, VA).

Material examined. 5 ♀♀, all on slides. **USA. Illinois.** Montgomery Co.: Litchfield, 13.vii.1910, A. Girault (1♀, USNM); Champaign Co.: Urbana, 9.vi.1910 and 5.v.1911, A. Girault (2 ♀ ♀, USNM). **Virginia.** Fairfax Co.: Arlington experimental farm, no date, F.W. Poos, ex. *Chaetocnema denticulata* (2♀ ♀, USNM).

Hosts and Biology. *Chaetocnema denticulata* (Illiger) (Chrysomelidae). Poos (1955) noted the

maximum developmental time of 11 days in *C. denticulata* eggs exposed to *A. pullicrurus* in the laboratory. He reared females only. Apparently, only one individual developed within each host egg, but this was not definitely established.

Comments. Three specimens besides the type series were mentioned by Girault (1910). One female collected June 9 in a greenhouse is on a slide together with six *Anagrus armatus* (Ashmead). The latter species undoubtedly is a misidentification other species of *Anagrus*, as explained by Chiappini *et al.* (1996: 573). It has short, inconspicuous thoracic setae and a FWL/FWWof 6.97 (left wing) and 6.40 (right wing). I treat it as probably *A. pullicrurus*. A male collected July 1, 1910, is on a slide together with seven *Camptoptera pulla* Girault. It appears to belong to *A. gerrisophaga* on the basis of its long, prominent head and thoracic setae but its forewing is too broad to be *A. gerrisophaga*; it has a FWL/FWW of only 6.59 (wings obliquely positioned so width of one wing and length of other wing measured to obtain ratio). The second male that Girault (1910) also collected on July 1 was not found.

On the basis of known hosts, *A. gerrisophaga* should be restricted to near or on water whereas *A. pullicrurus* should be in fields (which of course may be near water so *A. gerrisophaga* could easily disperse into them). The collection locality of the type series of *A. pullicrurus* does not help in determining a natural habitat. Dispersing or wind blown specimens could easily end up in a greenhouse regardless of the host they parasitize or the habitat they normally occupy. More material reared from *Chaetocnema* spp. is needed to search for better characters to define *A. pullicrurus* and assess its variation more thoroughly.

***Anaphes sordidatus* (Girault)**

(Figs. 14, 28, 47)

Anaphoidea sordidatus (Girault, 1909: 167) (original description).

Anaphes sordidatus; Huber *et al.*, 1997: 961 (type material, redescription, literature).

Type material. LECTOTYPE ♀ (INHS), examined (see Huber *et al.* 1997) from USA: Illinois, Centralia.

Diagnosis. Occipital suture straight (as in Fig. 30), ovipositor extending under gaster (Fig. 47), forewing (Fig. 28) with posterior margin narrowly brown at least distally, Fl_2 (Fig. 14) with 2 longitudinal sensilla, solitary in eggs of *Tyloderma foveolatum*. Statistics of the antennal segments are given in Table XXIV to complement the description in Huber *et al.* (1997) and for comparison with the antennal descriptions of the other species redescribed here. Type measurements are given in Table I.

This species cannot be distinguished morphologically from *A. listronoti*. One character that may possibly separate the species is the sculpture of the mesoscutal midlobe posteriorly. The sculpture consists of reticulate sculpture apparently arranged in somewhat longitudinal elliptical pattern compared to a more circular pattern in *A. listronoti*. Biologically, *A. listronoti* differs by being gregarious and having a different host, *Listronotus oregonensis*. The two species do not interbreed in the laboratory (Huber *et al.*, 1997). *Anaphes sordidatus* is similar to *A. victus* (Huber *et al.* 1997) and to specimens of *A. luna* that have Fl_2 with two longitudinal sensilla. Even though there is a difference in ovipositor length between *A. sordidatus* and *A. luna* and they appear to be morphologically distinct, it would be interesting to conduct crossing experiments between them to see if *A. sordidatus* is also biologically distinct.

Distribution. USA (IA, IL).

Anaphes victus Huber
(Figs. 15, 29, 48)

Anaphes victus (nomen nudum); Cormier *et al.*, 1996: 1376 (seasonal ecology, distribution).
Anaphes victus; Huber *et al.*, 1997: 967 (original description); van Baaren and Boivin, 1998a: 525 (genotypic and kin discrimmination); van Baaren and Boivin; 1998b: 10 (host discrimination); van Baaren *et al.*, 1999: 1 (antennal sensilla); van Baaren *et al.*, 1999: 67 (larval competition, sex allocation); Boivin and van Baaren, 2000: 1 (larval agression and mobility); Boivin and Nénon, 2003: 768 (effect of host egg chorion on parasitism); Boivin *et al.*, 2004: 641 (searching behavior).

Type material. HOLOTYPE ♀ (CNCI), examined (see Huber *et al.* 1997) from CANADA: Quebec, Ste. Clotilde.

Diagnosis. Occipital suture straight (as in Fig. 30), ovipositor extending under gaster (Fig. 48), forewing (Fig. 29) with posterior margin narrowly brown at least distally, Fl_2 (Fig. 15) with 1 or 2 longitudinal sensilla, solitary in eggs of *Listronotus oregonensis*. The ovipositor is shorter than in *A. sordidatus*, and *A. listronoti* which is morphologically the most similar species to *A. victus*. Possibly, *A. victus* is the same as *A. luna*, as discussed under the latter.

Statistics of the antennal segments (Tables XXV and XXVI) are given to complement the description in Huber *et al.* (1997) and for comparison with the antennal descriptions of the other species redescribed here. Type measurements are given in Table I. See diagnosis of *A. listronoti* for additional features to separate it from *A. victus*.

Distribution. Canada (QC), USA (MI, TX).

Comments. This solitary species (only one adult emerges from one host egg) is very similar to specimens reared from *Hypera postica* since the mid-1950's and identified as *A. luna*. Crossing experiments betwen *A. victus* from *L. oregonensis* on carrot and *A. luna* from *H. postica* on alfalfa should be undertaken to see if they are the same species.

Table I. Measurements (in μm) of primary types of nominal *crassicornis*-group species of *Anaphes* for North America. Abbreviations used: HT=holotype; L=length; LMC=longest marginal cilia of wings; LT=lectotype; Macro. dist.=distance between macrochaetae of marginal vein; ovip.=ovipositor; PT=paratype; Troch.=trochanter; W=width. Many measurements could not be made because parts were missing or not clearly visible. Measurements of structures positioned obliquely are not accurate, and are indicated by " ".

Nominal species	Type	Head W	Mesosoma		Ovip. L	Ovip./hind tibia
			W	L		
1. *pallipes*	HT	193	-	220	330	≈2.06
1a. *pallipes* (remounted)		≈204	-	215	311	1.9
2. *sordidatus*	LT	-	-	285	494	1.71
3. *luna*	HT	-	-	247	300	1.32
4. *calendrae*	HT	≈232	-	≈257	614	≈2.17
5. *brunneus*	HT	-	-	≈222	313	≈1.47
6. *confertus*	HT	≈215	-	248	184	0.89
7. *gerrisophagus*	HT	≈172	128	218	≈267	-
8. *conotracheli*	PT	233	-	274	452	1.96
9. *longiclava*	HT	≈152	-	191	190	1.18
10. *pullicrurus*	HT	≈170	-	242	304	1.43
11. *diana*	LT	≈217	169	229	≈139	≈0.61
12. *cotei*	HT	248	-	272	440	1.66
13. *listronoti*	HT	251	-	303	484	1.74
14. *victus*	HT	235	-	283	368	1.40

Nominal species	Forewing			Total ven.	Macro dist. L	Stigmal L	Marginal space L
	L	W	LMC				
1. *pallipes*	519	-	-	185	48	29	121
1a. *pallipes*	526	114	131	192	47	28	116
2. *sordidatus*	827	151	131	273	76	34	99
3. *luna*	701	107	149	226	56	31	86
4. *calendrae*	710	98	143	238	63	35	117
5. *brunneus*	620	123	148	193	37	31	88
6. *confertus*	707	118	142	211	52	27	118
7. *gerrisophagus*	636	62	123	215	60	35	100
8. *conotracheli*	669	147	125	241	55	35	116
9. *longiclava*	489	92	134	170	40	29	71
10. *pullicrurus*	604	83	116	217	57	29	91
11. *diana*	648	98	126	223	53	31	106
12. *cotei*	766	94	249	250	69	33	115
13. *listronoti*	789	136	133	275	67	40	131
14. *victus*	709	127	127	238	62	35	70

Table I. – continued

Nominal species	Hind wing			Ven.L	Forewing L/W
	L	W	LMC		
1. *pallipes*	-	-	-	-	-
1a. *pallipes*				4.62	
2. *sordidatus*	805	35	122	272	5.48
3. *luna*	661	21	101	217	6.57
4. *calendrae*	694	28	118	226	7.26
5. *brunneus*	575	27	104	198	5.04
6. *confertus*	658	34	123	207	6.02
7. *gerrisophaga*	625	19	99	193	10.29
8. *conotracheli*	-	31	-	-	4.55
9. *longiclava*	482	21	101	163	5.33
10. *pullicrurus*	587	23	91	199	7.30
11. *diana*	637	28	113	212	6.59
12. *cotei*	736	28	118	236	8.13
13. *listronoti*	-	32	118	-	5.82
14. *victus*	696	28	119	235	5.58

Nominal species	Foreleg				Tarsus				
	Coxa	Troch.	Femur	Tibia	Total	1	2	3	4
1. *pallipes*	≈53	38	99	99	≈105	≈30	≈27	≈26	≈24
1a. *pallipes*	≈64	40	≈101	≈102	≈107	31	29	26	≈20
2. *sordidatus*	-	59	184	187	177	53	44	41	37
3. *luna*	-	37	≈137	≈117	133	≈37	35	34	26
4. *calendrae*	≈95	54	180	176	167	51	41	35	32
5. *brunneus*	≈78	36	144	137	137	40	34	35	28
6. *confertus*	85	-	131	118	109	30	27	25	27
7. *gerrisophagus*	67	42	≈140	-	121	35	29	27	30
8. *conotracheli*	87	46	162	≈142	156	44	38	38	35
9. *longiclava*	67	34	119	113	119	31	27	28	33
10. *pullicrurus*	80	43	≈130	129	123	40	29	27	27
11. *diana*	-	≈59	-	155	143	41	36	34	32
12. *cotei*	88	52	167	174	176	60	40	39	46
13. *listronoti*	104	53	≈189	≈174	179	56	43	43	38
14. *victus*	94	≈50	≈167	158	144	41	38	33	32

Table I. – continued

Nominal species	Middle leg				Tarsus				
	Coxa	Troch.	Femur	Tibia	Total	1	2	3	4
1. *pallipes*	50	39	119	≈131	-	-	-	-	-
1a. *pallipes*	38	35	122	≈124					
2. *sordidatus*	75	50	190	-	182	45	54	47	37
3. *luna*	≈62	40	143	≈190	140	32	42	36	29
4. *calendrae*	78	-	≈180	247	179	60	44	41	32
5. *brunneus*	≈47	41	132	177	126	31	34	33	29
6. *confertus*	≈64	35	137	171	118	27	31	30	29
7. *gerrisophagus*	43	36	146	179	126	35	33	29	29
8. *conotracheli*	57	28	154	203	136	32	38	37	29
9. *longiclava*	≈39	-	124	146	-	24	26	17	26
10. *pullicrurus*	47	38	135	187	135	35	36	33	29
11. *diana*	≈50	40	-	219	134	31	36	35	32
12. *cotei*	64	50	175	258	164	49	43	39	32
13. *listronoti*	67	58	≈162	≈247	177	50	46	44	37
14. *victus*	69	57	173	240	145	33	38	39	35

Nominal species	Hind leg				Tarsus				
	Coxa	Troch.	Femur	Tibia	Total	1	2	3	4
1. *pallipes*	82	46	≈135	161	-	-	-	-	-
1a. *pallipes*	78	43	142	165					
2. *sordidatus*	134	71	219	285	194	50	55	48	40
3. *luna*	≈151	61	172	226	140	27	44	40	27
4. *calendrae*	≈125	62	206	285	187	65	44	42	34
5. *brunneus*	85	52	160	196	125	31	33	32	29
6. *confertus*	100	59	161	207	≈139	25	33	38	32
7. *gerrisophagus*	≈74	≈36	-	-	137	38	35	33	30
8. *conotracheli*	103	65	183	231	148	33	42	40	31
9. *longiclava*	76	43	130	161	92	22	23	19	27
10. *pullicrurus*	91	52	155	213	146	35	42	36	35
11. *diana*	≈77	53	-	232	152	36	43	37	37
12. *cotei*	112	64	201	≈263	175	50	48	44	35
13. *listronoti*	117	65	≈214	≈280	191	50	53	49	23
14. *victus*	115	65	200	265	159	35	50	43	35

Table 1. – continued

Nominal species	Scape		Pedicel		Funicle article (number of longitudinal sensilla)												Clava			
					1		2		3		4		5		6		Total		1	2
	L	L	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	L
1. *pallipes*	≈84	22	40	≈30	22	13	33	16	41	21(2)	33	20	47	28(2)	43	-(2)	-	-	-	-
1a. *pallipes*	≈71	23	41	26	23	13	36	14	43	20(2)	38	17	51	28(2)	-	-	-			
2. *sordidatus*	143	33	52	26	26	17	90	24(2)	84	23(2)	83	22(2)	79	23(2)	72	22(2)	123	41	50(2)	73(4)
3. *luna*	-	-	46	26	22	14	51	14	56	14(2)	50	16(2)	54	15(2)	52	19(2)	91	-	-	-
4. *calendrae*	-	36	53	30	27	17	77	16	74	20(2)	72	24(2)	66	23(2)	64	23(2)	120	39	49(2)	68(4)
5. *brunneus*	-	24	43	24	25	15	59	13	56	17(1)	47	14	56	20(2)	53	20(2)	102	33	35(2)	68(4)
6. *confertus*	-	36	50	26	21	15	28	17	35	20(2)	24	20	32	21(2)	34	22(2)	107	36	34(2)	72(4)
7. *gerrisophagus*	100	27	45	25	20	12	43	12	57	17(2)	47	17(1/0)	53	19(2)	53	21(2)	102	29	43(2)	59(4)
8. *conotracheli*	100	27	47	31	26	16	49	16	63	22(2)	56	23(2)	61	23(2)	58	23(2)	106	35	42(2)	63(4)
9. *longiclava*	≈70	21	41	26	20	13	34	13	45	17(2)	41	16(1)	47	16(2)	45	19(2)	92	26	36(2)	59(4)
10. *pullicrurus*	113	-	46	25	19	14	44	14	58	22(2)	53	22(2)	54	24(2)	52	25(2)	107	37	42(2)	65(4)
11. *diana*	111	30	47	26	23	14	38	16	55	20(2)	59	20(2)	60	20(2)	56	20(2)	122	35	42(2)	79(4)
12. *cotei*	≈150	27	54	26	27	14	79	14	86	18(2)	79	21(2)	77	21(2)	71	23(2)	123	37	53(2)	70(4)
13. *listronoti*	125	33	51	27	31	18	78	18(1)	82	22(2)	81	22(2)	77	22(2)	74	23(2)	122	36	55(2)	67(4)
14. *victus*	125	29	≈44	28	25	16	≈66	16(1)	65	19(2)	65	19(2)	60	21(2)	63	21(2				

TABLE II. Statistics of antennal segments of *Anaphes brunneus*. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	90 (0.8) 93-106 (n=3)	23 (n=1)	3.86 (n=1)
pedicel	44 (2) 42-46 (n=3)	29 (n=1)	1.48 (n=1)
Fl_1 (n=3)	25(0.6) 24-26	14 (0.9) 13-15	1.82 (0.15) 1.69-1.98
Fl_2 (n=3)	66 (7) 58-70	6 (1.1) 13-15	4.65 (0.29) 4.39-4.96
Fl_3 (n=3)	60 (3.6) 57-64	17 (4.8) 14-23	3.61 (0.80) 2.80-4.39
Fl_4 (n=3)	53 (6) 47-59	16 (1.1) 15-17	3.37 (0.46) 3.1-3.9
Fl_5 (n=3)	60 (3) 57-63	20 (3.2) 18-24	3.04 (0.52) 2.54-3.0
Fl_6 (n=3)	58 (1.2) 56-59	23 (1.5) 21-24	2.58 (0.16) 2.54-2.76
clava (n=2)	108 (3.2) 106-110	33 (4.9) 29-36	3.36 (0.60) 2.92-.3.78

Table III. Statistics of antennal segments of *Anaphes calendrae* females ex. *Sphenophorus costipennis* [adult length 9-13 mm, from Vaurie (1951)]. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	130 (5.6) 123-138 (n=7)	35 (1.6) 33-38 (n=11)	3.78 (0.20) 3.59-4.18 (n=5)
pedicel	55 (2.8) 52-60 (n=16)	30 (1.8) 28-34 (n=13)	1.87 (0.10) 1.62-1.99 (n=13)
Fl_1	27 (2.4) 22-32 (n=16)	18 (1.1) 16-20 (n=16)	1.53 (0.18) 1.24-1.80 (n=15)

Table III. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_2	72 (4.8) 66-81 (n=17)	16 (1.0) 14-18 (n=17)	4.39 (0.39) 3.92-4.96 (n=13)
Fl_3	73 (2.9) 70-79 (n=17)	22 (2.5) 18-26 (n=17)	3.38 (0.50) 2.74-4.33 (n=16)
Fl_4	68 (4.7) 64-84 (n=18)	23 (2.3) 19-27 (n=17)	2.99 (0.52) 2.52-4.52 (n=16)
Fl_5	66 (3.4) 58-72 (n=18)	24 (1.6) 21-27 (n=18)	2.74 (0.26) 2.40-3.21 (n=17)
Fl_6	62 (2.4) 56-66 (n=18)	24 (1.6) 22-27 (n=17)	2.57 (0.24) 2.21-2.95 (n=17)
clava	121 (3.6) 113-127 (n=18)	38 (2.7) 32-41 (n=17)	3.18 (0.23) 2.52-3.64 (n=17)

Table IV. Statistics of antennal segments of *Anaphes calendrae* females ex. *Sphenophorus destructor* (adult length 8-11 mm). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length	width	ratio (L/W)
scape	119 (7.8) 109-122 (n=4)	32 (3.6) 28-36 (n=4)	3.92 (0.32) 3.55-4.14 (n=3)
pedicel (n=7)	54 (1.7) 52-56	29 (2.8) 26-33	1.86 (0.19) 1.6-2.07
Fl_1 (n=7)	27 (2.4) 24-31	17 (1.8) 13-19	1.65 (1.18) 1.43-1.93
Fl_2 (n=7)	70 (11.7) 53-80	16 (1.3) 15-19	4.36 (0.63) 3.54-5.03
Fl_3 (n=7)	70 (8.4) 57-77	21 (2.2) 18-24	3.38 (0.36) 2.89-3.82

Table IV. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_4	65 (7.8)	23 (2.1)	2.90 (0.30)
(n=7)	53-72	21-27	2.41-3.23
Fl_5	63 (7.1)	23 (1.3)	2.79 (0.24)
(n=7)	52-68	20-25	2.34-3.05
Fl_6	60 (6.7)	23 (2.3)	2.59 (0.22)
(n=7)	50-67	19-26	2.17-2.83
clava	118 (7.0)	38 (2.2)	3.12 (0.04)
(n=7)	108-127	35-40	3.07-3.16

Table V. Statistics of antennal segments of *Anaphes calendrae* females ex. *Sphenophorus maidis* (adult length 12-16 mm). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length	width	ratio (L/W)
scape	149 (11.7)	40 (3.2)	3.33
	141-158	38-42	(n=1)
	(n=2)	(n=2)	
pedicel	64 (3.6)	34 (1.1)	1.86 (0.16)
(n=2)	60-67	33-35	1.74-1.97
Fl_1	34 (2.7)	21 (2.4)	1.64 (0.31)
(n=3)	31-36	19-23	1.33-1.94
Fl_2	92 (4.1)	19 (0.6)	4.95 (0.17)
(n=3)	88-96	18-19	4.83-5.15
Fl_3	98 (3.5)	25 (2.3)	3.98 (0.24)
(n=3)	93-102	22-27	3.72-4.20
Fl_4	25 (1.6)	26 (2.0)	3.27 (0.22)
(n=3)	84-87	25-29	3.02-3.44
Fl_5	79 (1.8)	27 (1.4)	2.88 (0.19)
(n=3)	77-80	26-28	2.72-3.09
Fl_6	72 (2.7)	27 (0.3)	2.70 (0.04)
(n=3)	70-74	26-27	2.65-2.74
clava	133 (6.0)	42 (3.8)	3.23 (0.28)
	126-136	40-45	3.03-3.43
	(n=2)	(n=3)	(n=2)

Table VI. Statistics of antennal segments of *Anaphes calendrae* females ex. *Sphenophorus minimus* (adult length 5-7 mm). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length	width	ratio (L/W)
scape	103 (7.1) 91-109 (n=6)	30 (2.9) 27-34 (n=6)	3.67 (0.48) 3.33-4.01 (n=3)
pedicel	46 (2.4) 43-49 (n=10)	28 (2.3) 25-33 (n=10)	1.41 (0.18) 1.25-1.85 (n=9)
Fl_1	21 (1.8) 18-23 (n=13)	15 (0.9) 14-17 (n=12)	1.48 (0.15) 1.15-1.70 (n=12)
Fl_2	49 (7.4) 32-59 (n=14)	148 (1.2) 13-17 (n=14)	3.38 (0.47) 2.26-3.94 (n=13)
Fl_3 (n=14)	53 (7.8) 34-64	19 (2.4) 15-22	2.90 (0.36) 1.96-3.49
Fl_4 (n=15)	50 (5.6) 37-59	19 (2.1) 15-23	2.63 (0.26) 2.10-3.04
Fl_5 (n=15)	50 (5.3) 37-56	20 (2.8) 15-25	2.49 (0.26) 2.04-2.83
Fl_6 (n=15)	47 (4.3) 37-53	21 (2.3) 16-24	2.32 (0.20) 1.97-2.66
clava (n=15)	103 (8.2) 84-112	35 (1.9) 31-38	2.96 (0.25) 2.51-3.38

Table VII. Statistics of antennal segments of *Anaphes calendrae* females ex. *Sphenophorus parvulus* (adult length 6-8 mm). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length	width	ratio (L/W)
scape	103 (9.6) 92-121 (n=7)	29 (3.8) 20-33 (n=9)	3.36 (0.23) 3.41-3.97 (n=5)
pedicel	45 (3.5) 38-52 (n=12)	27 (1.4) 26-29 (n=9)	1.65 (0.10) 1.51-1.84 (n=9)

Table VII. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_1	22 (4.0)	15 (1.4)	1.49 (0.25)
	16-29	13-17	1.18-2.09
	(n=13)	(n=14)	(n=13)
Fl_2	52 (9.1)	16 (2.0)	3.37 (0.67)
	39-74	13-22	2.36-4.75
	(n=16)	(n=16)	(n=15)
Fl_3	56 (5.6)	19 (1.9)	3.00 (0.27)
	45-70	15-22	2.60-3.58
	(n=17)	(n=16)	(n=16)
Fl_4	52 (5.6)	20 (2.1)	2.62 (0.20)
(n=17)	44-65	16-24	2.31-3.21
Fl_5	51 (5.9)	21 (1.9)	2.44 (0.22)
	41-64	18-25	2.13-3.07
	(n=17)	(n=15)	(n=15)
Fl_6	48 (5.3)	21 (2.5)	2.30 (0.25)
(n=17)	38-60	17-26	1.94-2.78
clava	105 (7.1)	35 (3.0)30-40	3.06 (0.25)
	92-116	30-40	2.68-3.57
	(n=17)	(n=15)	(n=15)

Table VIII. Statistics of antennal segments of *Anaphes calendrae* females ex. *Sphenophorus pertinax* (adult length 10.5-17 mm). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length	width	ratio (L/W)
scape	130 (9.6)	33 (3.5)	3.91 (0.16)
	113-134	28-37	3.8-4.02
	(n=5)	(n=5)	(n=2)
pedicel	53 (3.7)	28 (2.6)	1.87 (0.15)
(n=9)	48-60	22-31	1.72-2.19
	(n=9)	(n=9)	(n=9)
Fl_1	26 (1.8)	16 (1.3)	1.62 (0.16)
(n=11)	22-28	14-18	1.34-1.92
Fl_2	70 (9.8)	16 (1.1)	4.26 (0.45)
	57-86	15-18	3.79-4.94
	(n=12)	(n=12)	(n=11)

Table VIII. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_3	73 (1.0)	20 (2.3)	3.65 (0.68)
	57-85	17-23	2.75-4.95
	(n=12)	(n=12)	(n=11)
Fl_4	65 (8.3)	22 (2.3)	3.04 (0.44)
(n=14)	51-77	18-24	2.23-4.05
Fl_5	63 (7.2)	23 (2.2)	2.81 (0.22)
(n=15)	50-73	19-26	2.22-3.52
Fl_6	60 (6.9)	23 (2.1)	2.55 (0.17)
(n=15)	47-67	21-27	2.21-2.84
clava	114 (7.7)	38 (2.1)	2.98 (0.17)
(n=12)	101-125	35-43	2.74-3.24

Table IX. Statistics of antennal segments of *Anaphes calendrae* females ex. *Sphenophorus venatus vestitum* (adult length 8-11 mm). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length	width	ratio (L/W)
scape	114 (9.1)	30 (2.3)	3.87 (0.17)
(n=11)	98-123	25-34	3.60-4.11
pedicel	50 (2.1)	28 (1.4)	1.84 (0.06)
(n=11)	47-53	26-30	1.72-1.91
Fl_1	24 (2.7)	15 (0.9)	1.57 (0.15)
(n=11)	20-28	14-17	1.34-1.78
Fl_2	56 (7.2)	15 (0.8)	3.81 (0.42)
(n=10)	47-68	14-16	3.25-4.36
Fl_3	59 (5.4)	19 (1.6)	3.15 (0.23)
(n=10)	52-65	16-22	2.78-3.46
Fl_4	55 (4.8)	19 (1.3)	2.84 (0.14)
(n=10)	49-62	17-21	2.60-3.0
Fl_5	54 (4.9)	21 (1.3)	2.63 (0.20)
(n=10)	46-60	18-23	2.32-2.63
Fl_6	51 (4.1)	22 (1.1)	2.36 (0.17)
(n=10)	45-56	20-23	2.11-2.6
clava	106 (5.1)	35 (2.1)	3.01 (0.15)
(n=10)	98-113	32-38	2.79-3.38

Table X. Statistics of forewing of *Anaphes calendrae* females ex. various *Sphenophorus* spp. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

host	length	width	ratio (L/W)	LMC	marginal space
costipennis	717 (26.2) 671-761 (n=15)	98 (3.9) 89-106 (n=17)	7.28 (0.27) 6.79-7.81 (n=14)	131 (8.5) 118-143 (n=18)	123 (15.1) 101-154 (n=17)
destructor	703 (39.7) 619-738 (n=7)	99 (6.0) 89-109 (n=7)	7.11 (0.19) 6.80-7.26 (n=7)	133 (8.6) 121-143 (n=7)	112 (6.4) 100-119 (n=8)
maidis	861 (19.1) 847-882 (n=3)	129 (10.3) 122-141 (n=3)	6.68 (0.37) 6.26-6.97 (n=3)	142 (7.3) 133-146 (n=3)	152 (14.9) 140-169 (n=3)
minimus	565 (56.8) 436-634 (n=14)	77 (0.78) 63-86 (n=14)	7.37 (0.27) 6.92-7.80 (n=14)	123 (10.7) 105-124 (n=14)	113 (13.7) 97-137 (n=14)
parvula	598 (50.4) 497-671 (n=13)	76 (9.5) 60-94 (n=16)	7.75 (0.51) 6.69-8.62 (n=13)	122 (9.1) 104-137 (n=16)	115 (16.0) 84-137 (n=16)
pertinax	698 (68.0) 600-794 (n=13)	98 (11.3) 74-117 (n=13)	7.17 (0.32) 6.58-7.66 (n=13)	126 (7.3) 115-134 (n=13)	122 (14.6) 102-149 (n=14)
venustus *vestitum*	598 (50.8) 535-652 (n=9)	80 (7.6) 68-89 (n=9)	7.54 (0.28) 7.12-7.83 (n=9)	123 (8.6) 109-136 (n=9)	107 (9.7) 95-121 (n=8)

Table XI. Statistics of hind wing of *Anaphes calendrae* females ex. various *Sphenophorus* spp. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

host	length	width	LMC
costipennis	706 (33) 655-750 (n=13)	29 (2.3) 24-32 (n=18)	118 (6.4) 109-136 (n=18)
destructor	685 (42) 598-720 (n=7)	29 (2.1) 26-33 (n=8)	115 (7.0) 105-125 (n=8)
maidis	843 (15.6) 832-854 (n=2)	37 (2.5) 34-38 (n=3)	136 (2.2) 134-139 (n=3)
minimus	532 (39.4) 480-590 (n=12)	24 (2.8) 19-27 (n=15)	104 (9.4) 80-117 (n=15)
parvula	588 (53.5) 503-654 (n=12)	25 (2.5) 19-29 (n=17)	102 (11.6) 71-121 (n=17)

Table XI. – continued

host	length	width	LMC
pertinax	686 (77.0) 594-769 (n=10)	28 (2.2) 25-31 (n=15)	114 (7.6) 104-128 (n=15)
venustus vestitum	580 (53.5) 512-648 (n=8)	24 (1.8) 21-26 (n=9)	104 (7.4) 95-113 (n=9)

Table XII. Body statistics of *Anaphes calendrae* females ex. various *Sphenophorus* spp. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

host	head width	ovipositor length	hind tibial length	ratio (ovipositor L/ hind tibial L)
costipennis	238 (n=1)	605 (16.7) 571-632 (n=17)	277 (8.3) 268-290 (n=17)	2.19 (0.05) 2.12-2.30 (n=17)
destructor	260 (3.2) 257-263 (n=3)	587 (43.1) 512-631 (n=7)	268 (22.6) 247-292 (n=6)	2.14 (0.04) 2.10-2.20 (n=5)
maidis	301 (39.5) 273-329 (n=2)	748 (10.9) 736-751 (n=3)	347 (8.9) 337-353 (n=3)	2.15 (0.02) 2.14-2.18 (n=3)
minimus	215 (n=1)	461 (45.0) 356-516 (n=13)	203 (20.3) 188-236 (n=13)	2.25 (0.06) 2.18-2.37 (n=10)
parvula	199 (5.5) 195-203 (n=2)	493 (55.6) 400-571 (n=19)	216 (25.8) 174-240 (n=13)	2.27 (0.14) 2.09-2.64 (n=12)
pertinax	255 (16.0) 236-263 (n=5)	587 (60.7) 503-693 (n=14)	265 (29.8) 209-304 (n=15)	2.24 (0.06) 2.17-2.41 (n=14)
venustus vestitum	248 (22.1) 229-280 (n=4)	508 (37.4) 458-557 (n=11)	229 (18.4) 205-252 (n=11)	2.22 (0.07) 2.15-2.27 (n=11)

Table XIII. Statistics of antennal segments of *Anaphes confertus*. Means (in micrometers) on top, sample standard deviation in parentheses, number of measurements and range.

segment	length (L)	width (W)	ratio (L/W)
scape (n=3)	110 (5.2) 107-116	36 (4.8) 33-41	2.83 (0.61) 2.38-3.52
pedicel (n=3)	50 (6.3) 45-57	27 (1.3) 25-28	1.89 (0.32) 1.73-2.26
Fl_1	21 (1.5) 20-22 (n=2)	18 (1.9) 17-21 (n=4)	1.2 (0.03) 1.18-1.22 (n=2)

Table XIII. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_2	25 (4.4)	20 (1.7)	1.26 (0.26)
(n=4)	20-30	19-23	1.04-1.41
Fl_3	34 (3.6)	23 (2.3)	1.50 (0.21)
(n=4)	30-39	22-26	1.27-1.74
Fl_4	25 (2.9)	21 (1.1)	1.14 (0.14)
(n=4)	21-28	21-23	1.0-1.33
Fl_5	33 (3.0)	24 (2.0)	1.35 (0.07)
(n=4)	29-36	21-26	1.28-1.43
Fl_6	33 (2.6)	26 (3.6)	1.31 (0.10)
(n=4)	30-35	23-30	1.17-1.32
clava	115 (12.0)	41 (2.4)	2.82 (0.16)
	103-127	40-44	2.63-2.88
	(n=3)	(n=4)	(n=3)

Table XIV. Statistics of antennal segments of *Anaphes conotracheli* ex. *Conotrachelus* spp. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	99 (4.5)	29 (1.2)	3.48 (0.19)
	93-106	27-31	3.12-3.76
	(n=11)	(n=13)	(n=9)
pedicel	48 (1.4)	31 (2.2)	1.49 (0.07)
	45-50	26-34	1.39-1.61
	(n=12)	(n=14)	(n=9)
Fl_1	26 (1.7)	17 (0.8)	1.58 (0.10)
	23-30	15-18	1.43-1.76
	(n=14)	(n=14)	(n=13)
Fl_2	49 (3.3)	16 (1.0)	3.00 (0.16)
	41-53	16-18	2.72-3.27
	(n=14)	(n=13)	(n=13)
Fl_3	62 (3.2)	22 (1.7)	2.87 (0.27)
	54-67	20-26	2.23-3.38
	(n=15)	(n=14)	(n=13)
Fl_4	56 (3.3)	23 (1.5)	2.46 (0.24)
	50-60	21-25	2.14-2.91
	(n=14)	(n=13)	(n=11)

Table XIV. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_5	60 (2.6) 53-65 (n=15)	25 (2.5) 23-28 (n=15)	2.35 (0.23) 1.82-2.63 (n=12)
Fl_6	58 (2.4) 54-64 (n=15)	26 (2.3) 21-29 (n=15)	2.25 (0.22) 1.97-2.64 (n=12)
clava (n=16)	112 (5.1) 106-120 (n=16)	36 (2.4) 33-41 (n=13)	3.12 (0.23) 2.67-3.41 (n=12)

Table XV. Statistics of antennal segments of *Anaphes cotei* females. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape (n=4)	132 (2.5) 130-136	30 (1.3) 28-31	4.44 (0.15) 4.23-4.58
Pedicel (n=4)	55 (1.6) 54-58	30 (0.91) 29-31	1.84 (0.08) 1.76-1.95
Fl_1 (n=4)	27 (1.3) 26-29	16 (0.4) 16-17	1.67 (0.10) 1.54-1.78
Fl_2 (n=4)	82 (3.9) 78-87	16 (1.6) 15-18	5.17 (0.27) 4.86-5.32
Fl_3 (n=4)	85 (2.4) 83-88	20 (0.8) 19-20	4.27 (0.23) 4.14-4.62
Fl_4 (n=4)	79 (2.6) 76-82	20 (1.2) 19-22	3.87 (0.35) 3.61-4.38
Fl_5 (n=4)	75 (2.3) 72-77	21 (1.7) 19-23	3.56 (0.40) 3.10-4.05
Fl_6 (n=4)	71 (4.0) 62-77	23 (0.9) 22-24	3.13 (0.24) 2.82-3.36
Clava (n=4)	126 (2.0) 123-128	40 (3.7) 35-43	3.21 (0.29) 2.94-3.60

Table XVI. Statistics of antennal segments of *Anaphes diana*. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	106 (3.2)	25 (2.0)	4.35 (0.37)
(n=8)	101-110	22-28	3.66-4.67
pedicel	42 (2.3)	26 (1.3)	1.66 (0.11)
(n=11)	39-47	23-28	1.48-1.85
Fl_1	22 (1.8)	13 (0.5)	1.61 (0.16)
(n=11)	19-24	13-14	1.38-1.86
Fl_2	32 (2.2)	14 (0.8)	2.30 (0.20)
(n=11)	31-38	13-15	2.04-2.70
Fl_3	48 (3.6)	18 (1.9)	2.72 (0.27)
(n=11)	41-53	15-20	2.40-3.26
Fl_4	48 (4.1)	16 (1.9)	3.04 (0.24)
(n=11)	43-56	13-19	2.66-3.43
Fl_5	53 (2.2)	18 (1.8)	3.02 (0.32)
(n=11)	49-57	16-20	2.60-3.58
Fl_6	48 (2.5)	19 (2.5)	2.57 (0.32)
(n=10)	45-53	15-24	2.15-3.16
clava	109 (5.3)	27 (1.2)	4.09 (0.17)
(n=10)	101-121	25-29	3.87-4.37

Table XVII. Statistics of antennal segments of *Anaphes gerrisophaga*. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	97 (16)	23 (5)	4.10 (0.41)
	73-118	17-31	3.51-4.6
	(n=13)	(n=11)	(n=10)
Pedicel	43 (7)	24 (3)	1.83 (0.17)
	35-57	20-23	1.68-2.32
	(n=13)	(n=14)	(n=12)
Fl_1	21 (3)	12 (3)	1.68 (0.16)
(n=14)	17-27	10-15	1.45-2.03
Fl_2	41 (12)	13 (2)	3.33 (0.58)
	27-57	10-16	2.54-4.08
	(n=15)	(n=14)	(n=14)

Table XVII. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_3	54 (12)	18 (3)	2.97 (0.35)
(n=14)	37-69	14-22	2.31-3.48
Fl_4	47 (13)	19 (8)	2.79 (0.30)
	31-62	12-22	2.18-3.28
	(n=14)	(n=15)	(n=14)
Fl_5	52 (10)	20(3)	2.55 (0.22)
(n=14)	37-72	14-24	2.20-3.04
Fl_6	50 (8)	20 (2)	2.47 (0.22)
	37-60	17-24	2.23-3.03
	(n=14)	(n=13)	(n=13)
clava	100 (13)	34 (3)	2.96 (0.40)
	80-116	31-41	2.35-3.64
	(n=12)	(n=14)	(n=11)

Table XVIII. Statistics of antennal segments of *Anaphes listronoti*. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	117 (9.1)	32 (2.3)	3.75 (0.24)
	100-130	27-34	3.45-4.05
	(n=10)	(n=7)	(n=5)
pedicel	49 (3.1)	29 (1.7)	1.67 (0.08)
	44-55	27-33	1.58-1.82
	(n=13)	(n=10)	(n=10)
Fl_1	29 (2.5)	16 (1.1)	1.81 (0.16)
(n=13)	24-32	14-18	1.59-2.19
Fl_2	77 (10.4)	17 (2.4)	4.48 (0.51)
(n=13)	66-99	15-22	3.73-5.36
Fl_3	79 (8.0)	19 (1.8)	4.15 (0.48)
(n=13)	70-98	16-22	3.60-5.32
Fl_4	75 (7.6)	19 (2.6)	4.05 (0.59)
(n=13)	62-82	16-23	3.12-5.37
Fl_5	72 (6.8)	19 (2.6)	3.79 (0.50)
(n=13)	59-86	16-24	3.03-4.71

Table XVIII. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_6	68 (6.8)	20 (2.5)	3.48 (0.48)
(n=11)	55-80	16-25	2.68-4.17
clava	121 (80)	36 (3.0)	3.42 (0.16)
	108-131	31-41	3.23-3.61
	(n=11)	(n=8)	(n=8)

Table XIX. Statistics of antennal segments of *Anaphes longiclava*. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	83	25	3.32
(n=1)			
pedicel	43	29	1.48
(n=1)			
Fl_1	17	13	1.31
(n=1)			
Fl_2	38	14	2.71
(n=1)			
Fl_3	50	20	2.5
(n=1)			
Fl_4	46	18	2.26
(n=1)			
Fl_5	47	20	2.35
(n=1)			
Fl_6	45	21	2.14
(n=1)			
clava	101	29	3.48
(n=1)			

Table XX. Statistics of antennal segments of *Anaphes luna* (from specimens introduced in 1911 to Salt Lake City). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	86 (4.1)	25 (3.1)	3.59 (0.39)
(n=3)	83-93	21-29	3.24-4.01
pedicel	44 (3.3)	26 (1.9)	1.71 (0.09)

Table XX. – continued

segment	length (L)	width (W)	ratio (L/W)
	40-47	24-29	1.65-1.81
	(n=5)	(n=5)	(n=3)
Fl_1	20 (2.8)	13 (1.4)	1.58 (0.22)
	18-25	11-15	1.28-1.95
	(n=7)	(n=7)	(n=6)
Fl_2	46 (9.1)	14 (3.2)	3.19 (0.67)
	36-65	12-21	2.01-4.19
	(n=9)	(n=8)	(n=8)
Fl_3	53 (6.8)	18 (3.9)	3.07 (0.44)
	46-68	14-24	2.49-3.63
	(n=9)	(n=7)	(n=7)
Fl_4	49 (8.3)	16(3.6)	3.17 (0.44)
	40-64	13-22	2.23-3.63
	(n=9)	(n=8)	(n=8)
Fl_5	54 (4.2)	19 (0.3)	2.86 (0.41)
	49-63	15-24	2.42-3.50
	(n=9)	(n=8)	(n=8)
Fl_6	49 (5.4)	20 (3.0)	2.54 (0.49)
(n=8)	42-59	15-23	1.93-3.32
clava	99 (4.7)	35 (4.7)	2.88 (0.08)
	92-113	32-42	2.79-2.98
	(n=7)	(n=7)	(n=6)

Table XXI. Statistics of antennal segments of *Anaphes luna* (from specimens reared from 1958 on at various US localities). Means (in micrometers) and sample standard deviation in parentheses on top, number of specimens measured (in parentheses) and range.

segment	length (L)	width (W)	ratio (L/W)
scape	105 (6.7)	26 (2.3)	4.02 (0.39)
	92-116	21-30	3.63-4.94
	(n=14)	(n=14)	(n=9)
pedicel	45 (2.6)	26 (3.5)	1.68 (0.11)
	39-48	25-29	1.43-1.85
	(n=15)	(n=16)	(n=14)
Fl_1	22 (1.5)	14 (1.3)	1.54 (0.16)

Table XXI. – continued

segment	length (L)	width (W)	ratio (L/W)
	20-24	11-17	1.26-1.84
	(n=19)	(n=20)	(n=19)
Fl_2	58 (6.5)	16 (2.7)	3.57 (0.53)
(n=20)	45-71	13-21	2.62-4.64
Fl_3	64 (5.8)	21 (1.7)	3.10 (0.35)
(n=20)	57-73	18-24	2.38-4.0
Fl_4	59 (7.0)	20 (2.8)	2.98 (0.18)
	43-66	14-23	2.69-3.33
	(n=19)	(n=20)	(n=19)
Fl_5	60 (5.0)	22 (1.3)	2.75 (0.26)
	53-65	19-24	2.31-3.19
	(n=20)	(n=19)	(n=19)
Fl_6	60 (9.3)	23 (1.6)	2.49 (0.21)
	50-60	19-25	2.13-2.8
	(n=19)	(n=20)	(n=19)
clava	111 (5.9)	33 (4.1)	3.51 (0.19)
	94-119	30-33	3.07-3.75
	(n=19)	(n=16)	(n=15)

Table XXII. Statistics of antennal segments of *Anaphes pallipes* females ex. *Cylindrocopturus adspersus* (ND, Cass Co.) and from TX, Austin, Zilker Park. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	76 (4)	23 (2)	3.49 (0.19)
(n=6)	70-78	20-24	3.17-3.72
pedicel	41(2)	26(3)	1.59 (0.21)
(n=9)	38-44	19-29	1.33-2.04
Fl_1	20(2)	13(1)	1.54 (0.13)
(n=10)	17-23	12-15	1.27-1.73
Fl_2	33(3)	14(1)	2.45 (0.17)
(n=10)	30-38	12-15	2.00-2.60
Fl_3	45(3)	17(2)	2.70 (0.23)
(n=10)	38-51	12-21	2.45-2.92

Table XXII. – continued

segment	length (L)	width (W)	ratio (L/W)
Fl_4	34(2)	15(1)	2.25 (0.17)
(n=10)	30-39	13-16	2.06-2.52
Fl_5	48(3)	20(2)	2.41 (0.15)
(n=10)	43-53	17-23	2.14-2.71
Fl_6	44(4)	20(2)	2.2 (0.13)
(n=10)	38-51	17-22	2.00-2.36
Clava	94(5)	29(2)	3.22 (0.21)
(n=7)	88-97	26-31	2.92-3.48

Table XXIII. Statistics of antennal segments of *Anaphes pullicrurus* females. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	120 (5.5)	27 (1.9)	4.44 (0.19)
	112-124	24-29	4.22-4.65
	(n=4)	(n=5)	(n=4)
pedicel	45 (2.8)	26 (1.1)	1.78 (0.08)
	43-49	25-27	1.69-1.83
	(n=4)	(n=3)	(n=3)
Fl_1	21 (1.8)	13 (0.6)	1.55 (0.17)
	19-23	13-14	1.34-1.74
	(n=4)	(n=5)	(n=4)
Fl_2	43 (1.3)	14 (1.3)	3.14 (0.31)
(n=5)	42-45	12-16	2.67-3.49
Fl_3	56 (2.0)	21 (1.0)	2.64 (0.18)
	53-58	20-22	2.41-2.84
	(n=5)	(n=4)	(n=4)
Fl_4	53 (2.0)	22 (1.5)	2.41 (0.17)
(n=5)	51-56	21-25	2.17-2.61
Fl_5	53 (0.9)	21 (1.7)	2.58 (0.22)
(n=5)	52-54	20-24	2.20-2.74
Fl_6	51 (1.6)	22 (1.4)	2.32 (0.15)
(n=5)	49-53	20-24	2.11-2.44
Clava	108 (2.1)	38 (5.1)	2.84 (0.35)

Table XXIII. – continued

segment	length (L)	width (W)	ratio (L/W)
	106-110	33-46	2.40-3.23
	(n=4)	(n=5)	(n=4)

Table XXIV. Statistics of antennal segments of *Anaphes sordidatus* females. Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	130 (9.5)	34 (2.1)	3.80 (0.10)
	117-142	32-37	3.69-3.90
	(n= 5)	(n=6)	(n=5)
pedicel	54 (3.2)	30 (2.1)	1.77 (0.04)
(n=7)	49-57	27-32	1.70-1.80
Fl_1	29 (2.6)	17 (0.9)	1.72 (0.10)
(n=7)	26-32	16-19	1.57-1.84
Fl_2	81 (7.9)	21 (2.2)	3.97 (0.50)
(n=7)	71-93	17-23	3.42-4.83
Fl_3	76 (5)	22 (2.0)	3.50 (0.42)
	67-81	19-24	3.05-4.17
	(n=7)	(n=6)	(n=6)
Fl_4	74 (5.8)	22 (2.0)	3.31 (0.37)
	66-82	20-25	2.98-4.0
	(n=7)	(n=6)	(n=6)
Fl_5	72 (5.6)	23 (2.7)	3.09 (0.37)
	66-80	19-25	2.64-3.72
	(n=7)	(n=6)	(n=6)
Fl_6	68 (5.8)	24 (2.6)	2.77 (0.25)
	61-75	23-27	2.47-3.19
	(n=7)	(n=6)	(n=6)
Clava	119 (7.3)	36 (1.4)	3.32 (0.26)
(n=7)	109-129	33-37	2.95-3.73

Table XXV. Statistics of antennal segments of *Anaphes victus* females (from Quebec + Michigan specimens). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	117 (8.2) 107-126 (n=6)	28 (2.2) 26-31 (n=5)	4.12 (0.39) 3.54-4.76 (n=5)
pedicel	53 (5.1) 48-55 (n=8)	28 (1.6) 26-30 (n=7)	1.80 (0.09) 1.66-1.92 (n=6)
Fl_1	28 (2.3) 25-30 (n=8)	17 (1.2) 15-18 (n=7)	1.64 (0.11) 1.41-1.71 (n=7)
Fl_2	71 (6) 64-83 (n=7)	17 (1.3) 17-19 (n=8)	3.94 (0.30) 3.59-4.31 (n=7)
Fl_3 (n=8)	68 (4.2) 60-75	21 (2.4) 17-24	65 (3.7) 61-70
Fl_4 (n=8)	65 (3.7) 61-70	21 (2.5) 18-24	3.06 (0.32) 2.67-3.64
Fl_5 (n=8)	63 (3.8) 57-67	22 (2.5) 19-25	2.85 (0.28) 2.63-3.41
Fl_6 (n=8)	60 (3.3) 55-63	22 (3.4) 20-29	2.45 (0.24) 2.14-2.75
Clava	109 (6.3) 99-116 (n=8)	38 (4.0) 34-42 (n=5)	2.89 (0.29) 2.66-3.38 (n=5)

Table XXVI. Statistics of antennal segments of *Anaphes victus* females (from Texas specimens). Means (in micrometers) on top, sample standard deviation in parentheses, and range.

segment	length (L)	width (W)	ratio (L/W)
scape	103 (5.4) 96-112 (n=6)	25 (2.2) 22-28 (n=6)	4.10 (0.24) 3.76-4.36 (n=5)
pedicel (n=7)	46 (1.5) 43-48	26 (1.3) 24-27	1.78 (0.08) 1.73-1.94
Fl_1 (n=7)	22 (2.7) 19-28	14 (1.0) 13-16	1.55 (0.21) 1.27-1.85
Fl_2 (n=7)	51 (5.1) 44-57	15 (0.9) 14-16	3.5 (0.39) 3.03-4.03
Fl_3 (n=7)	58 (2.5) 54-62	19 (1.4) 17-21	3.09 (0.20) 2.91-3.16
Fl_4 (n=7)	55 (3.7) 49-61	20 (1.4) 18-22	2.74 (0.23) 2.50-3.21
Fl_5 (n=7)	54 (3.2) 50-60	20 (1.7) 17-22	2.71 (0.16) 2.47-2.89
Fl_6 (n=7)	51 (2.3) 48-56	21 (1.3) 19-23	2.46 (0.08) 2.33-2.57
Clava	103 (3.5) 98-109 (n=7)	31 (1.0) 30-33 (n=6)	3.20 (0.13) 2.51-3.36 (n=6)

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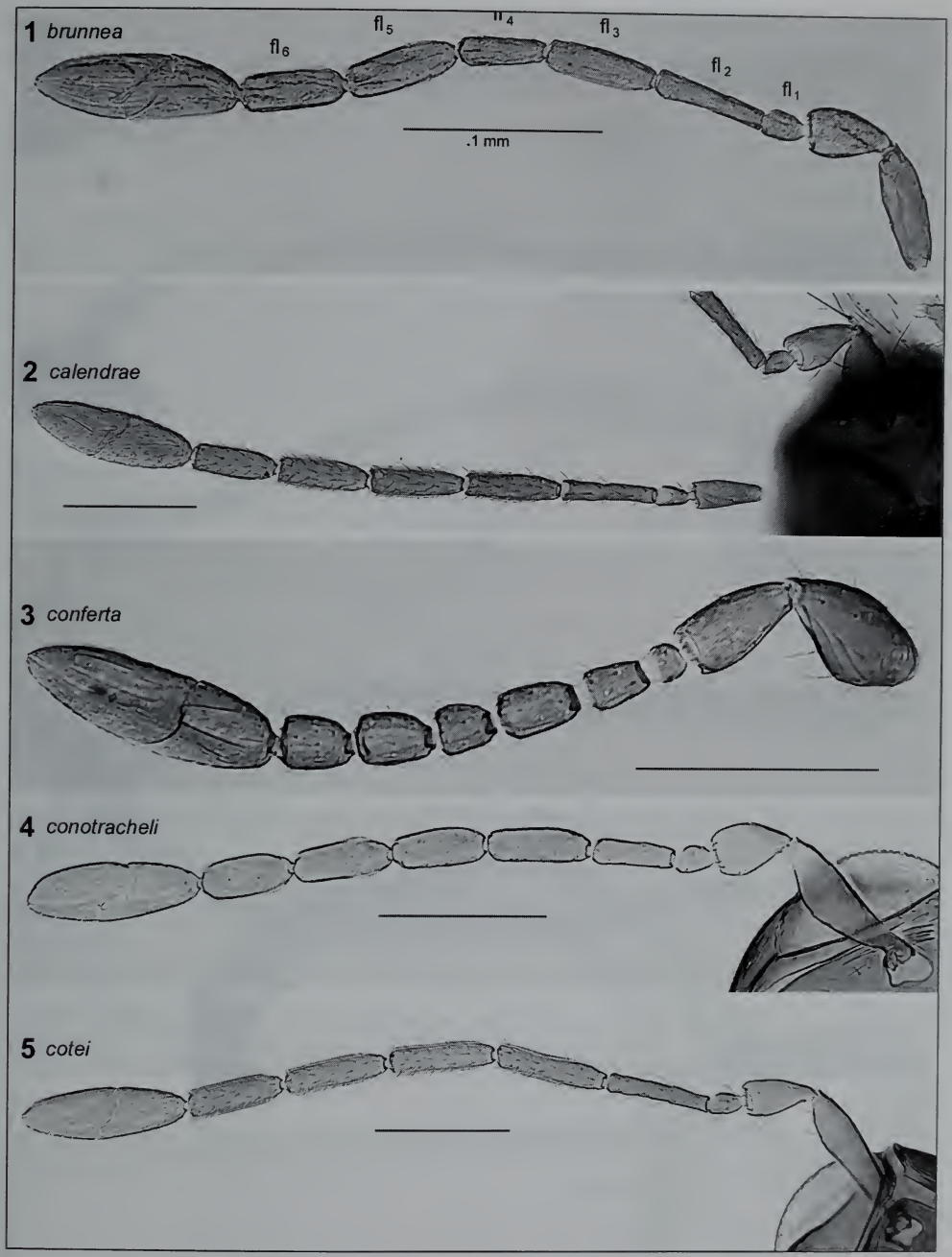
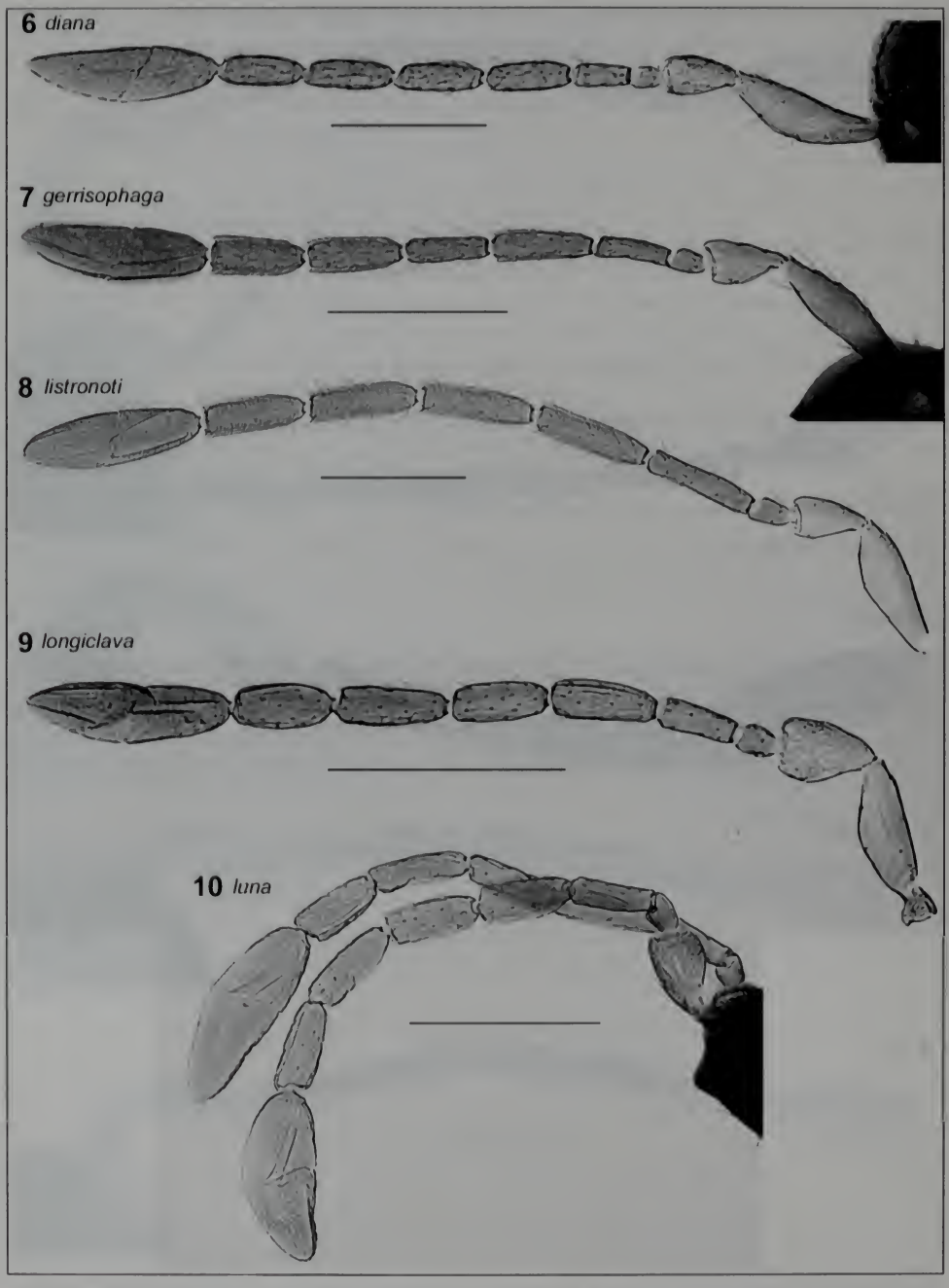
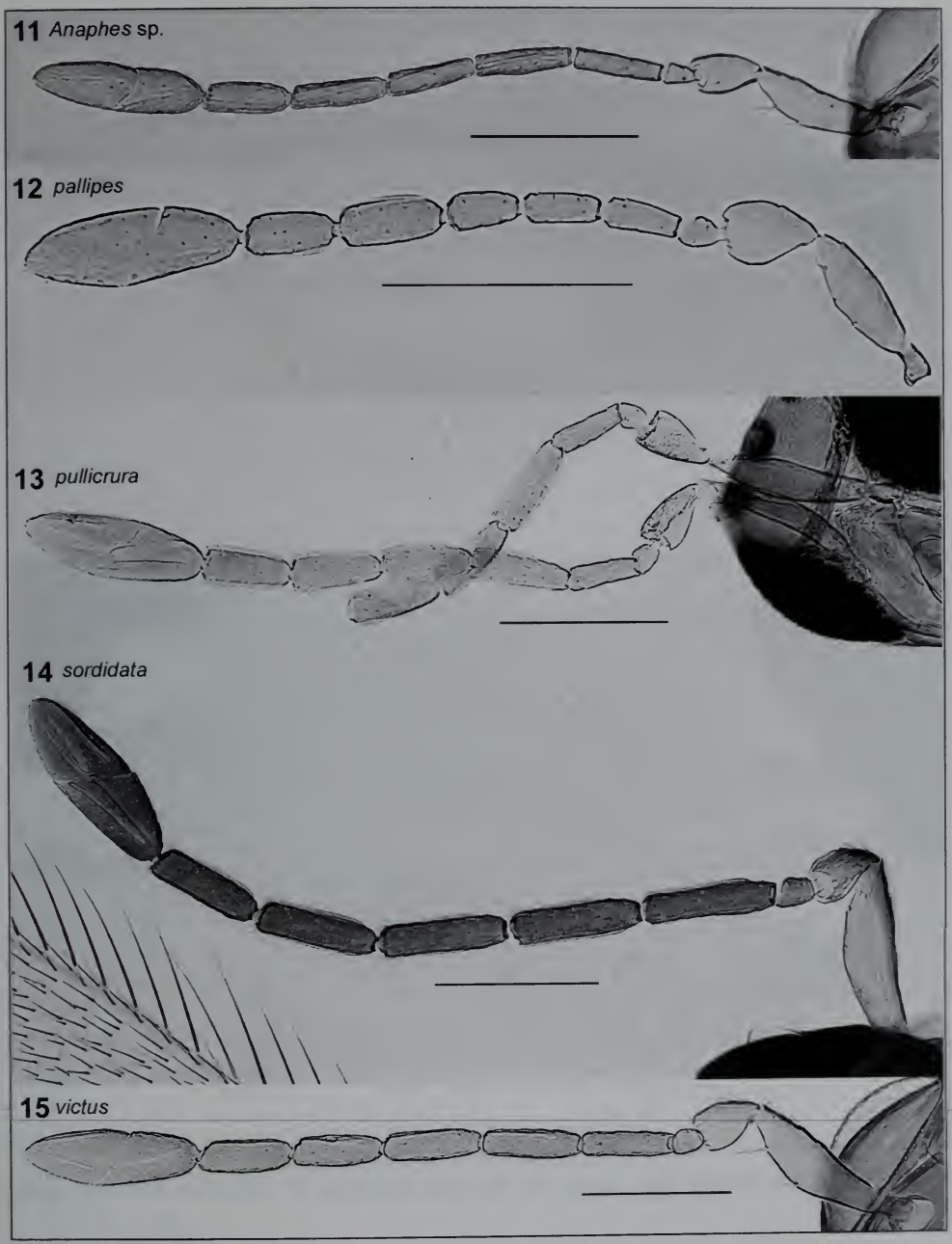


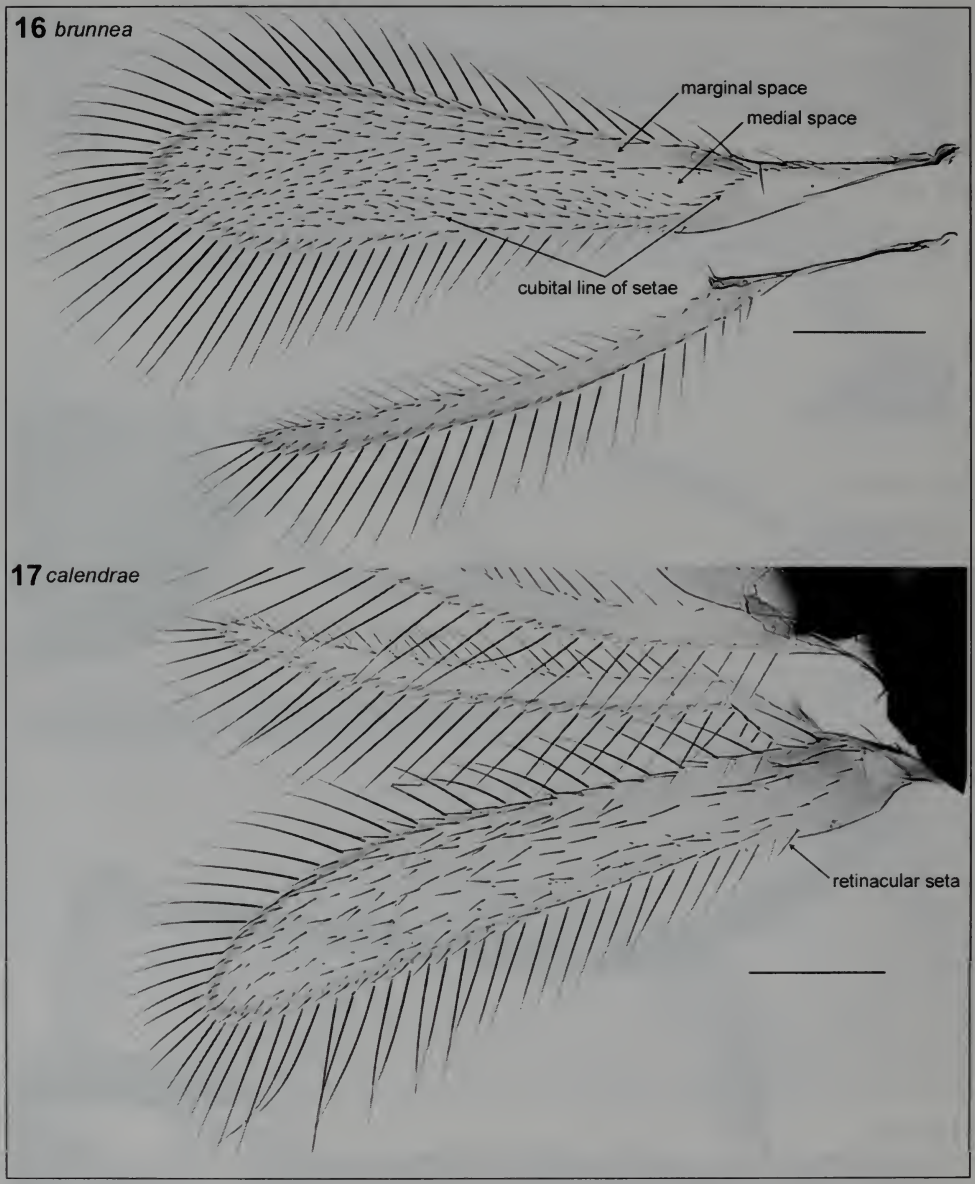
FIGURES 1-5. *Anaphes* spp., female antennae. 1, *brunneus*, holotype; 2, *calendrae*, holotype; 3, *confertus*, holotype; 4, *conotracheli*, paratype; 5, *cotei*, holotype. Scale bars = 0.1mm



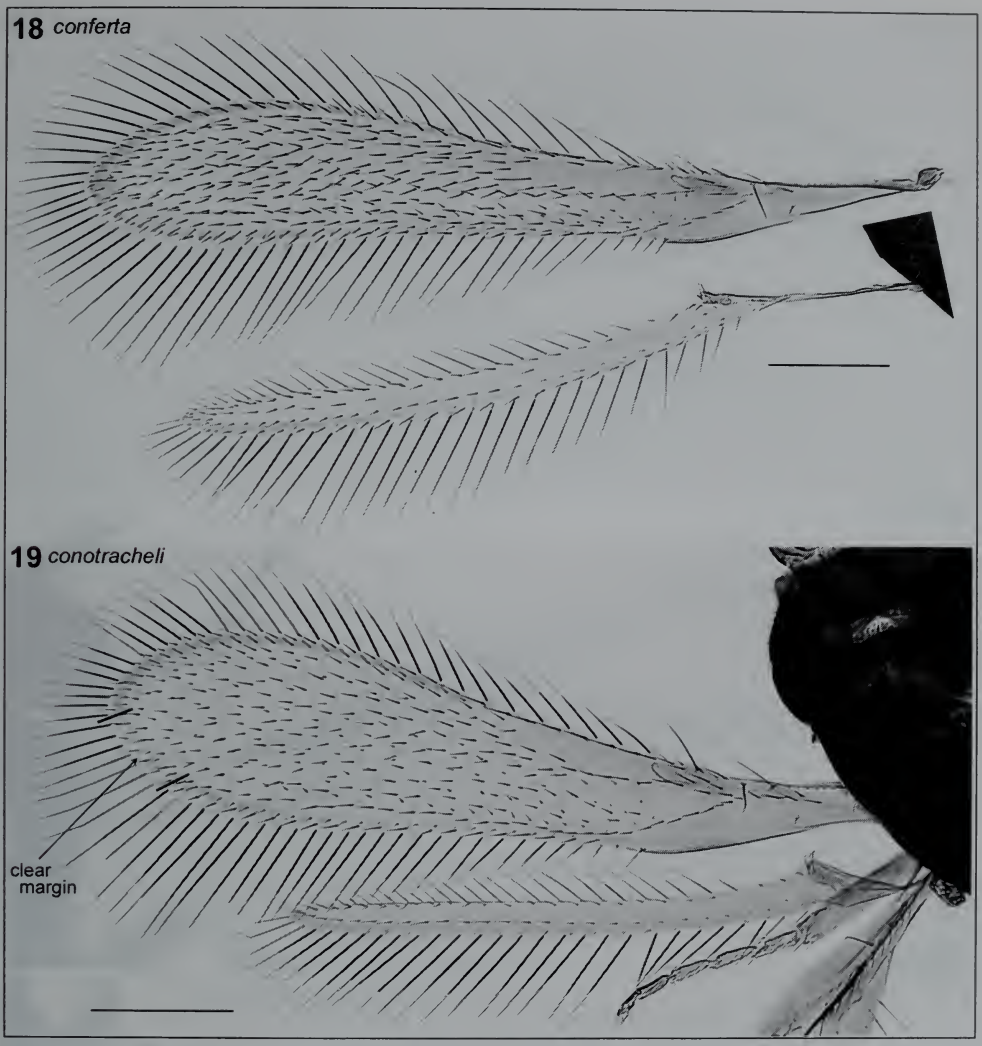
FIGURES 6-10. *Anaphes* spp., female antennae. 6, *diana*, lectotype; 7, *gerrisophaga*, holotype; 8, *listronoti*, holotype; 9, *longiclava*, holotype; 10, *luna*, paralectotype. Scale bars = 0.1mm



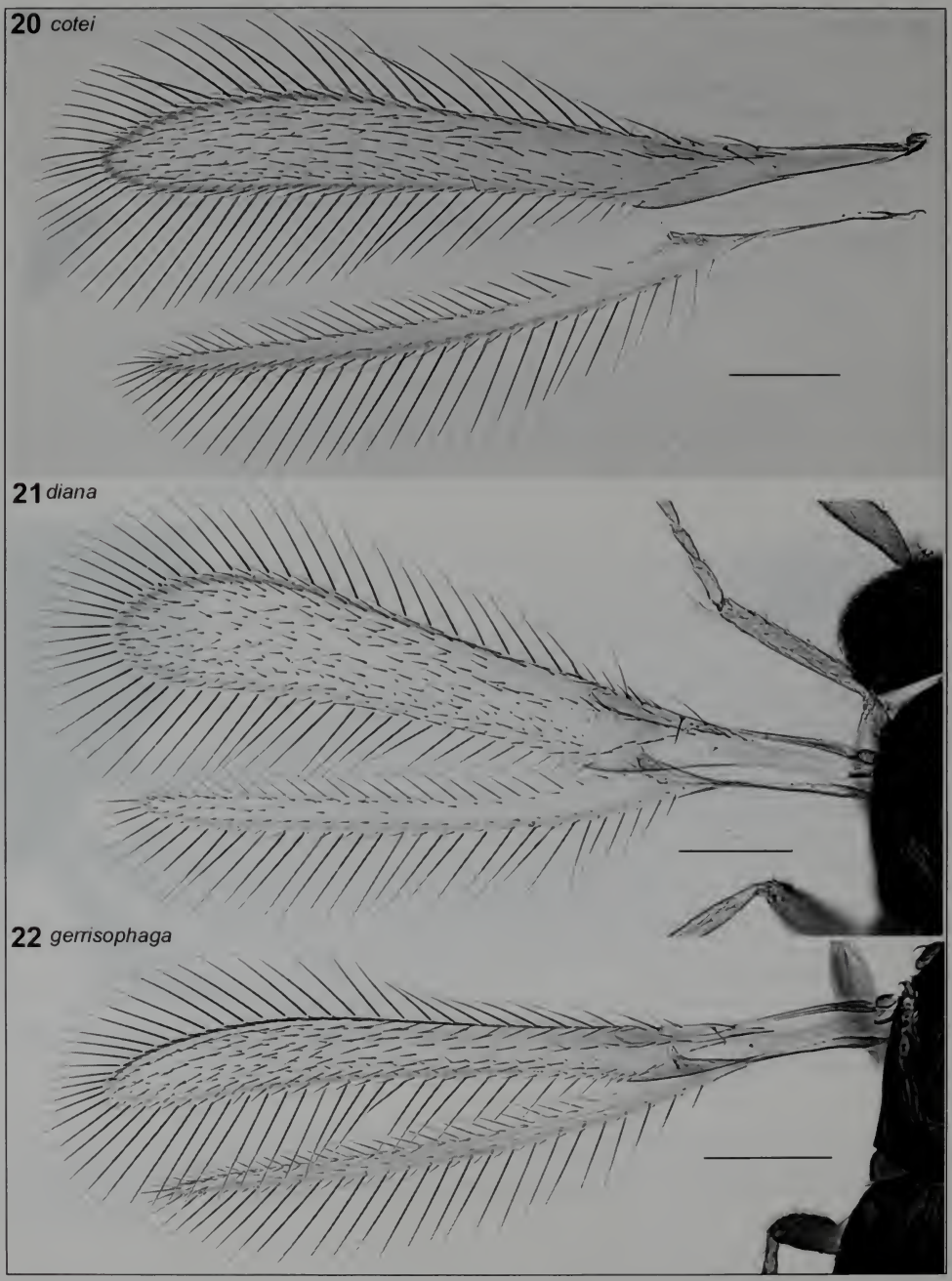
FIGURES 11-15. *Anaphes* spp., female antennae. 11, *A.* sp., not *luna*, ex. lab. culture on *Hypera postica*, WI, spring 1985, W. Gould; 12, *pallipes*, USA, TX, Travis Co., Austin, Zilker Park, 8.X.1983, J.B. Woolley; 13, *pullicrurus*, holotype; 14, *sordidatus*, lectotype; 15, *victus*, holotype. Scale bars = 0.1mm



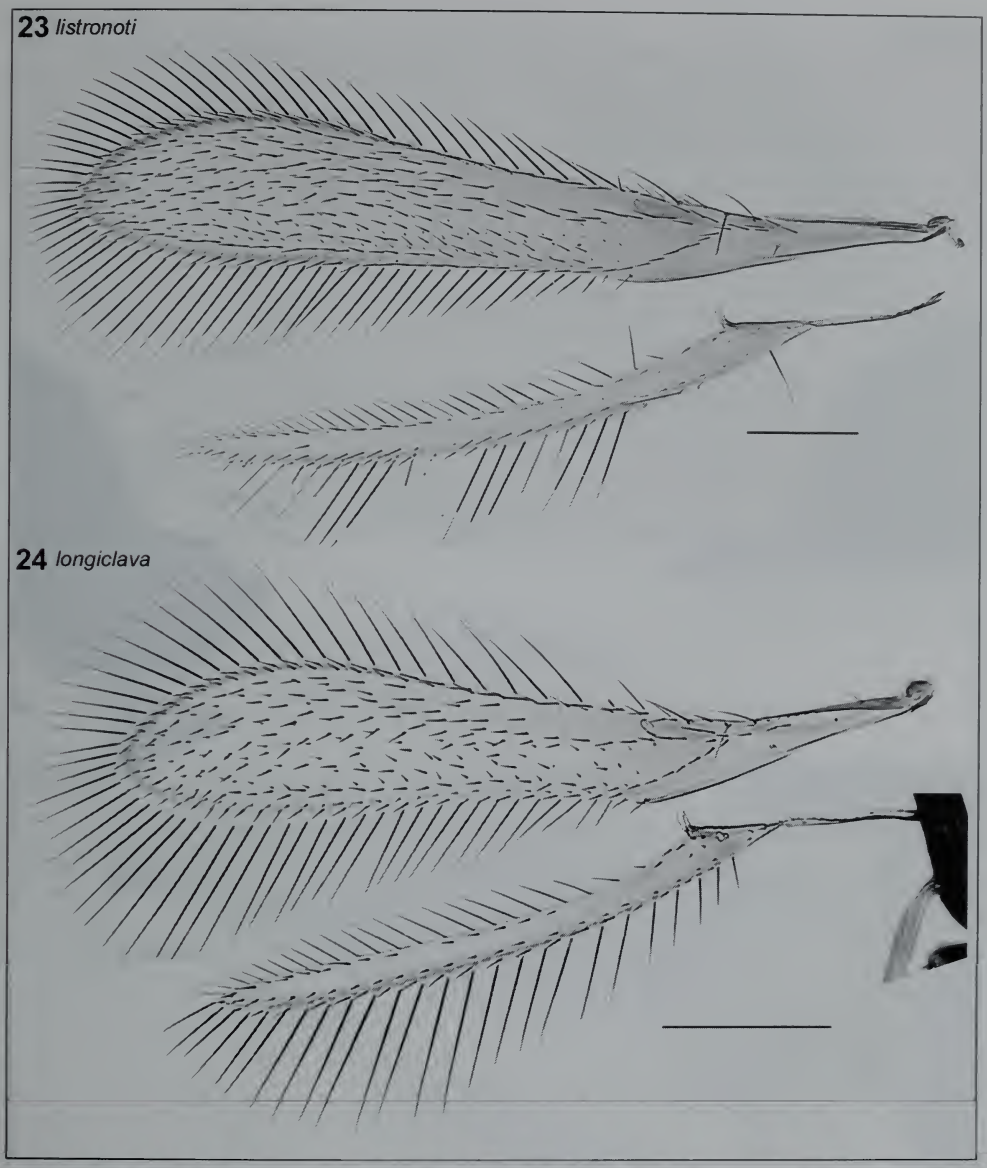
FIGURES 16, 17. *Anaphes* spp., wings. 16, *brunneus*, holotype; 17, *calendrae*, holotype. Scale bars = 0.1mm



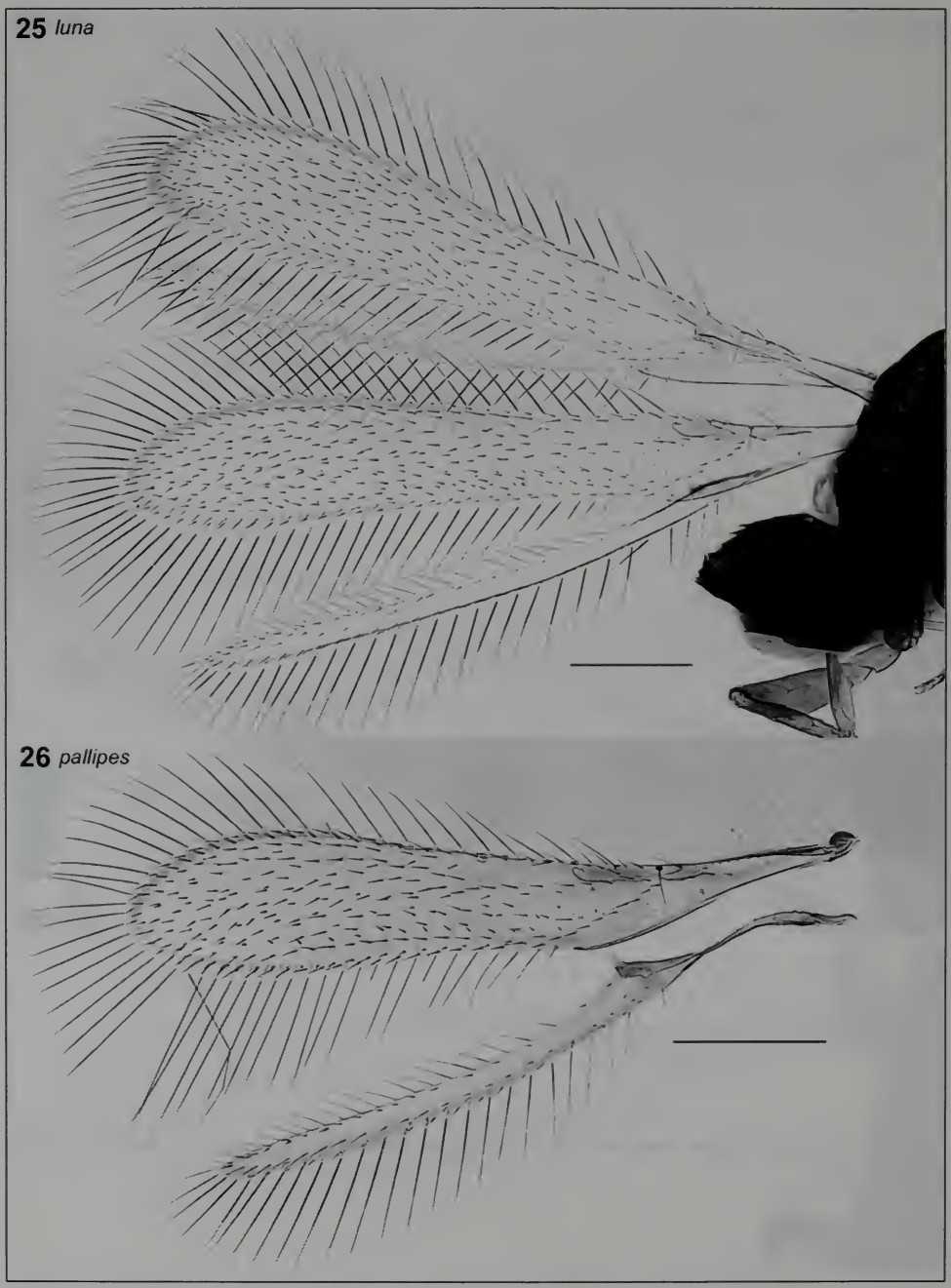
FIGURES 18, 19. *Anaphes* spp., wings. 18, *confertus*, holotype; 19, *conotracheli*, USA: MD, Arundel, #262. Scale bars = 0.1mm



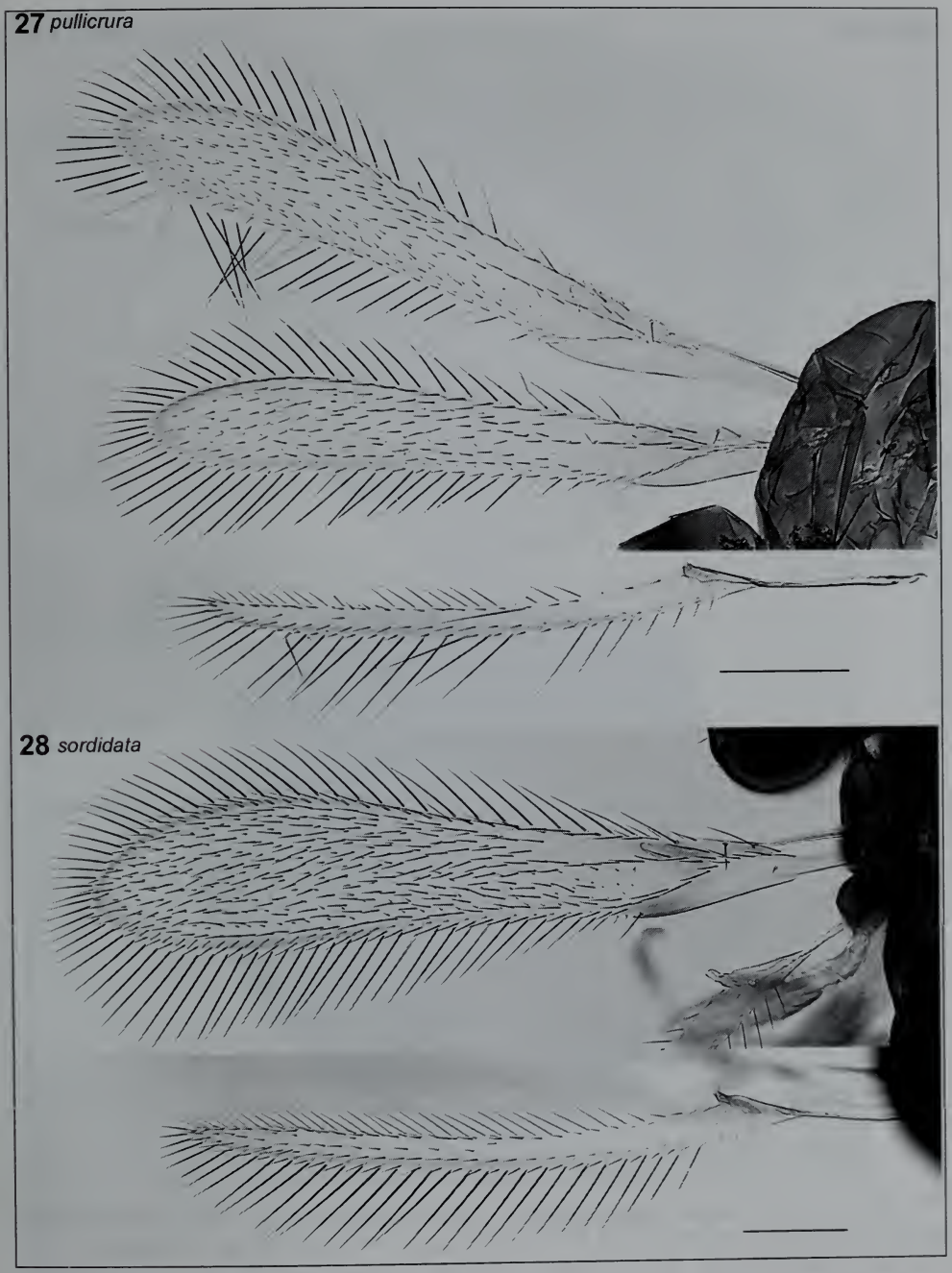
FIGURES 20-22. *Anaphes* spp., wings. 20, *cotei*, holotype; 21, *diana*, lectotype; 22, *gerrisophagus*, holotype. Scale bars = 0.1mm



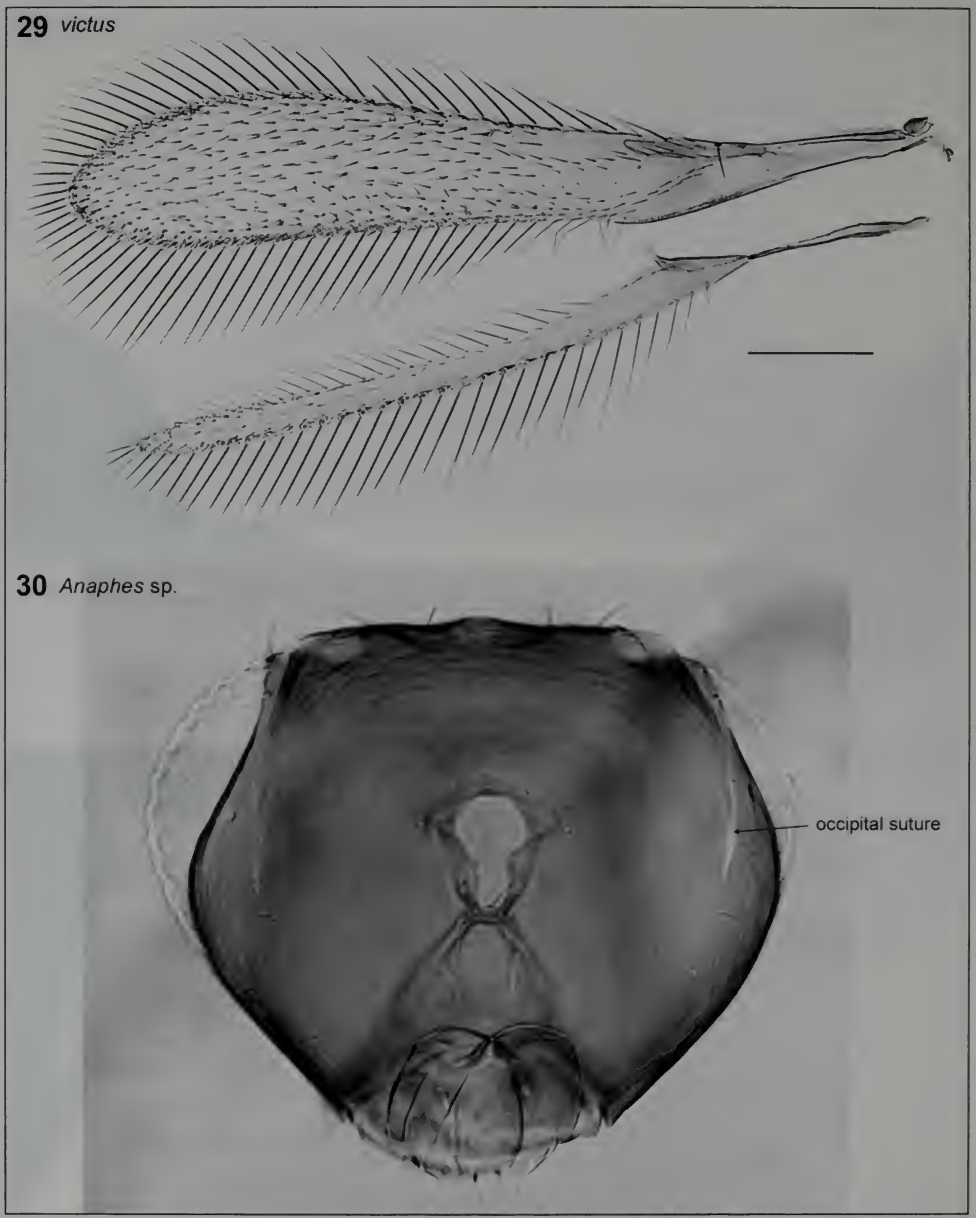
FIGURES 23, 24. *Anaphes* spp., wings. 23, *listronoti*, holotype; 24, *longiclava*, holotype. Scale bars = 0.1mm



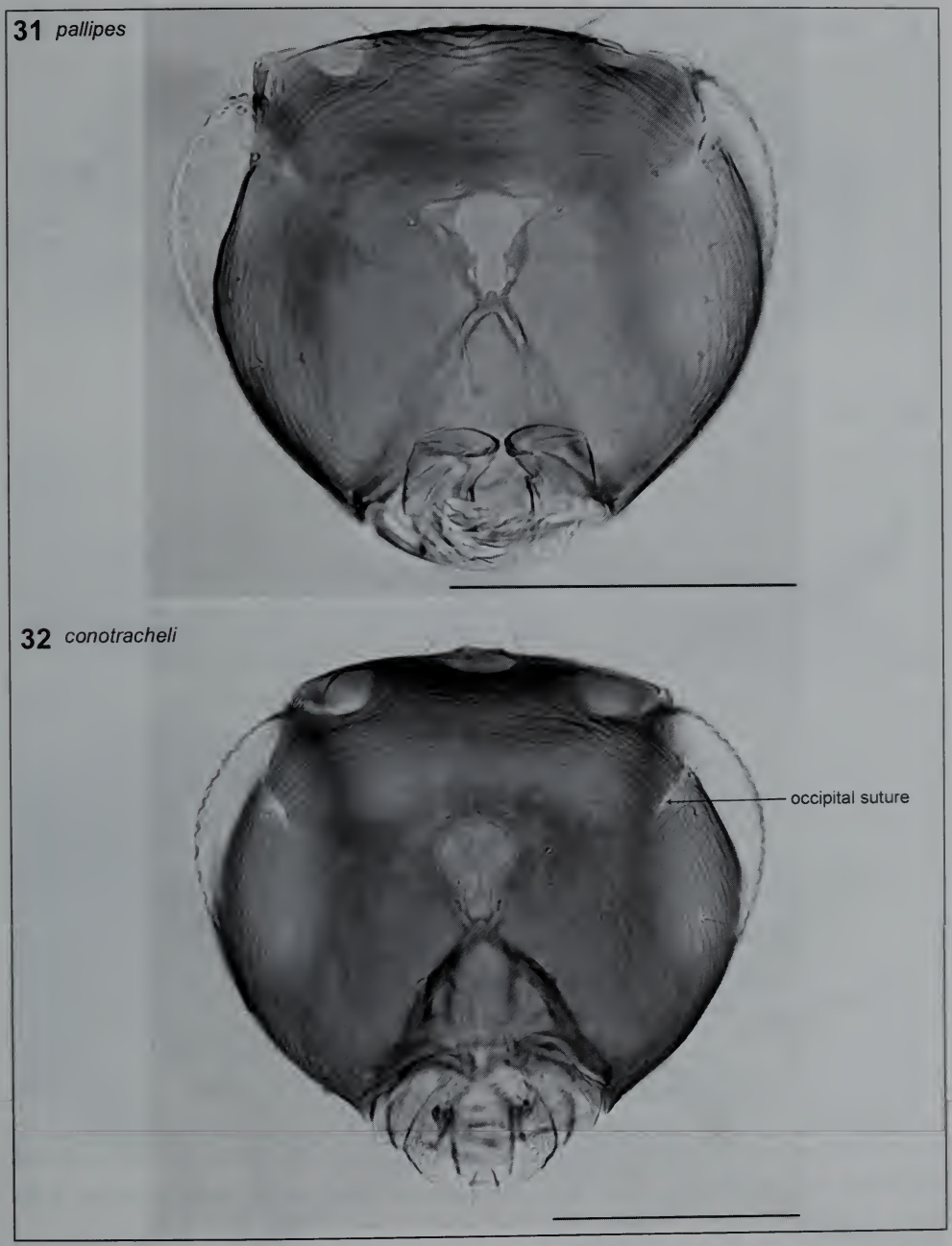
FIGURES 25, 26. *Anaphes* spp., wings. 25, *luna*, lectotype; 26, *pallipes*, USA, TX, Travis Co., Austin, Zilker Park, 8.x.1983, J.B. Woolley. Scale bars = 0.1mm



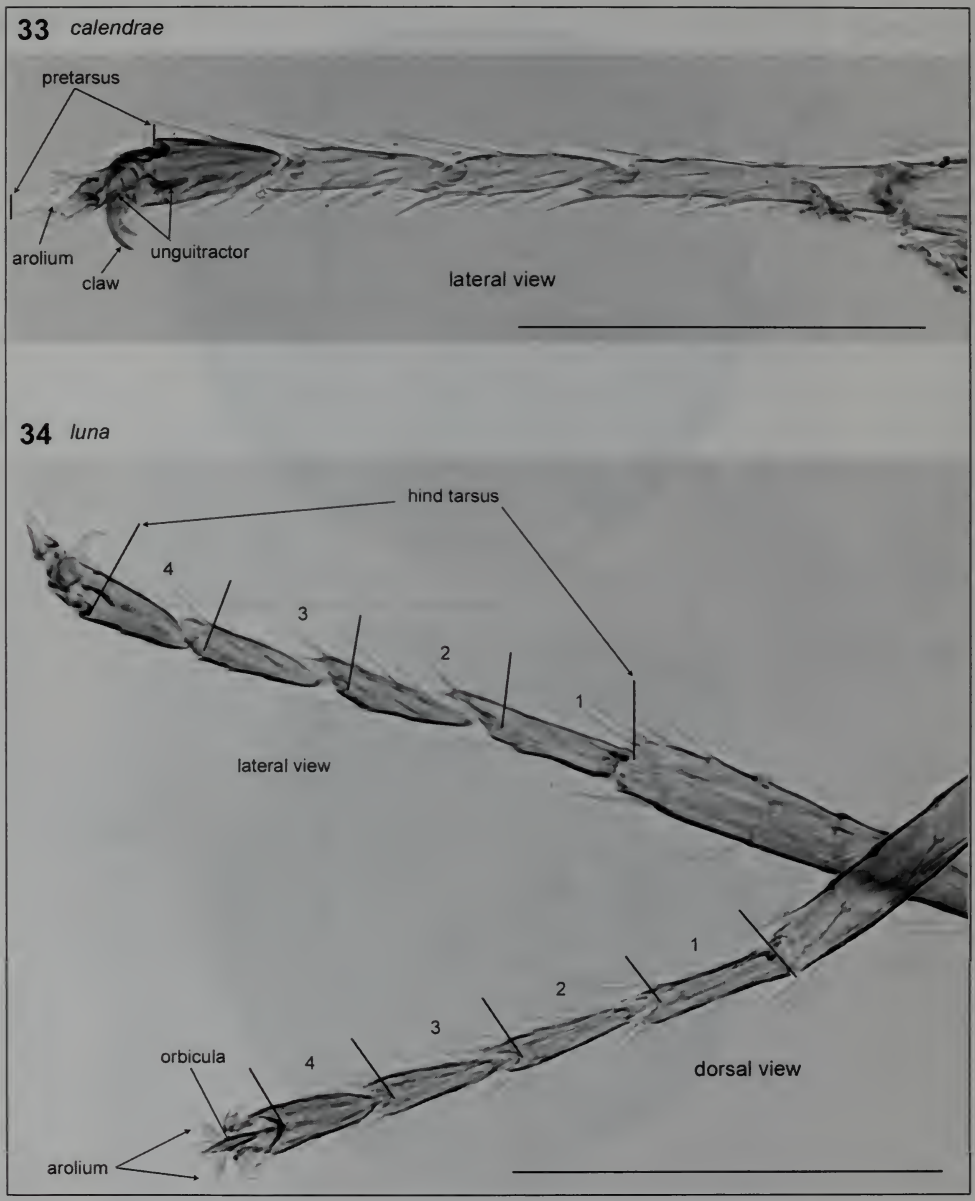
FIGURES 27, 28. *Anaphes* spp., wings. 27, *pullicrurus*, holotype; 28, *sordidatus*, lectotype. Scale bars = 0.1mm



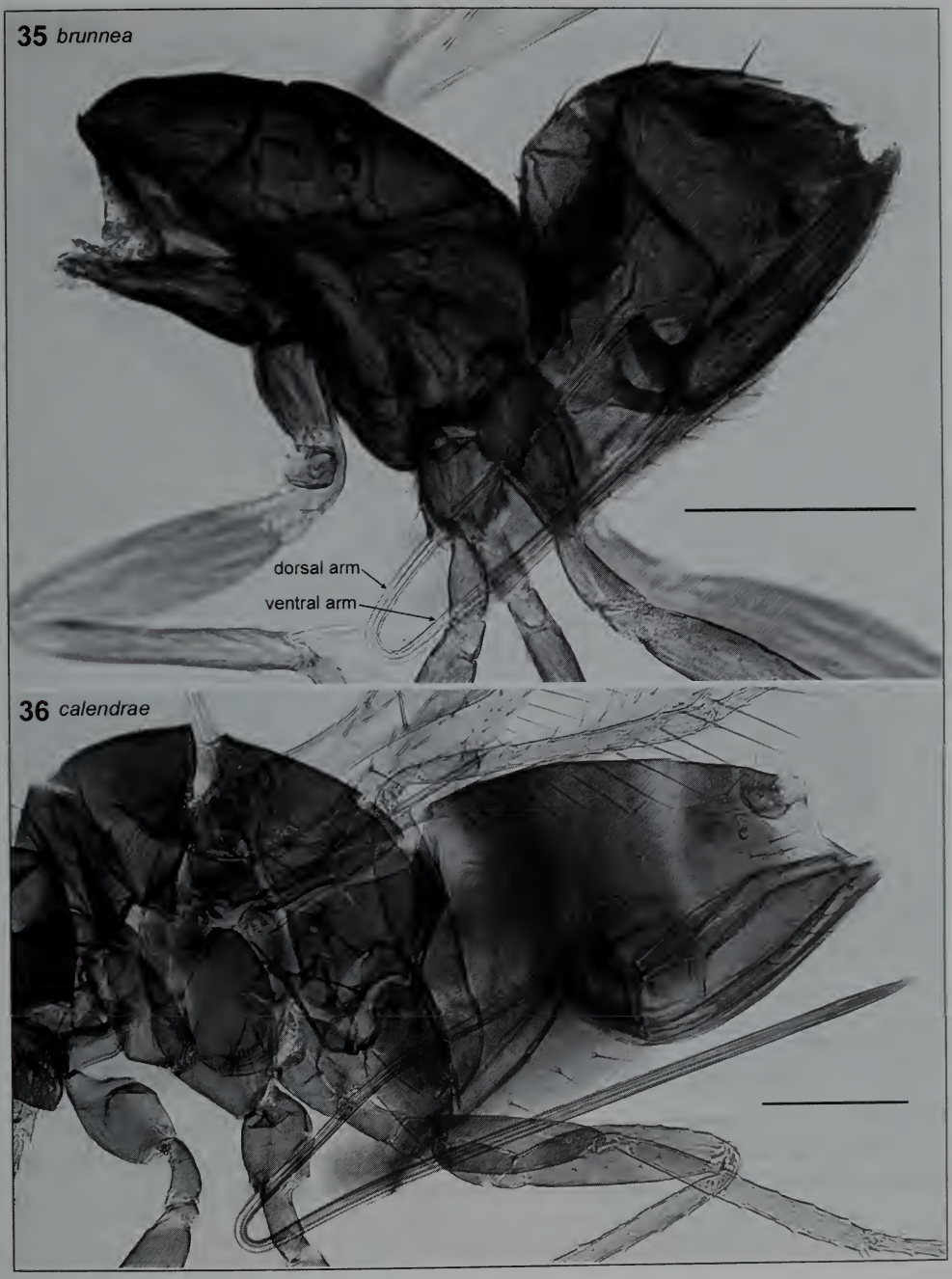
FIGURES 29, 30. *Anaphes victus*, holotype, wings; 30, *A.* sp. not *luna*, WI, Madison, spring, 1985, lab. culture ex. *Hypera postica*, W. Gould, Posterior of head. Scale bars = 0.1mm



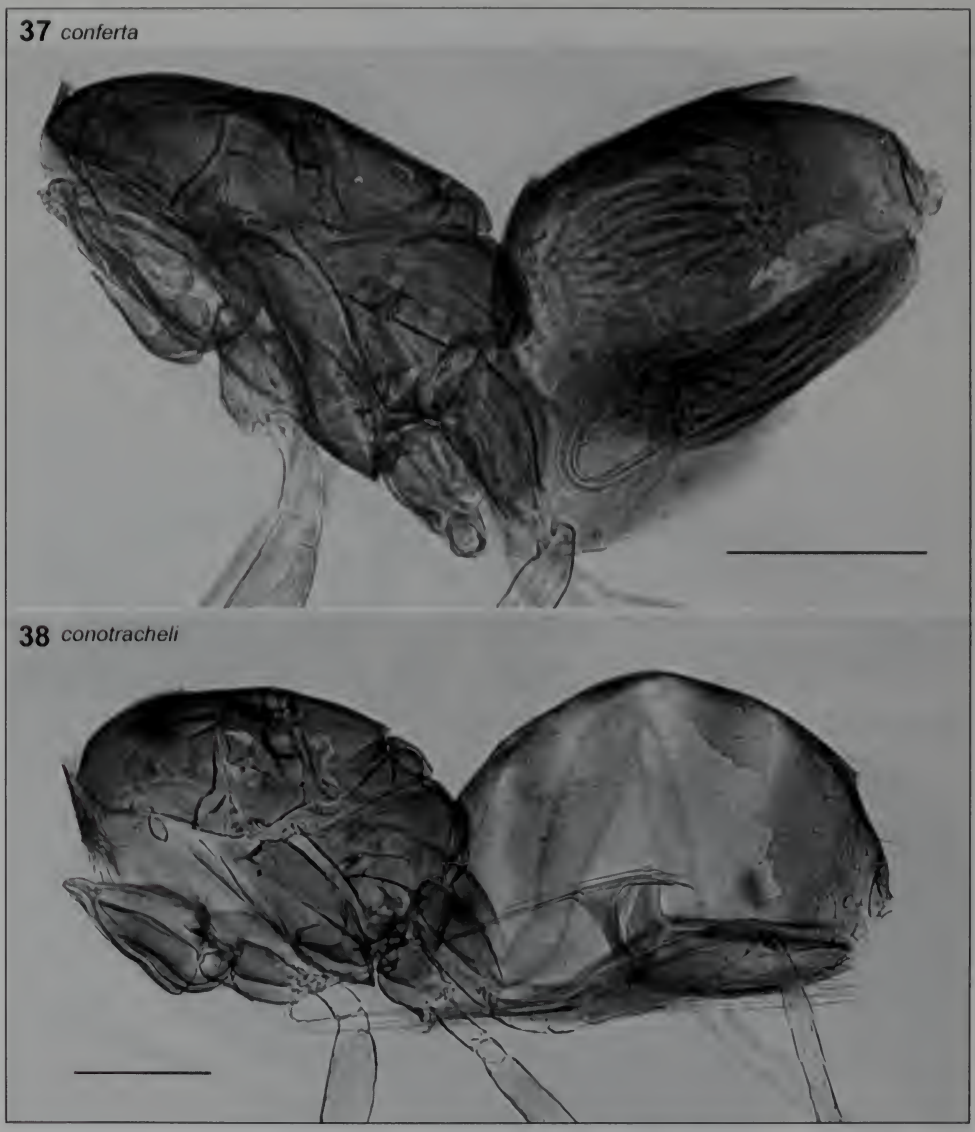
FIGURES 31, 32. *Anaphes pallipes*, Posterior of head. 31, ex. *Cylindrocopturus adspersus*, ND, Cass. Co.; 32, ex. lab. culture on *Listronotus oregonensis* but originally collected from *Conotrachelus geminatus*. Scale bars = 0.1mm



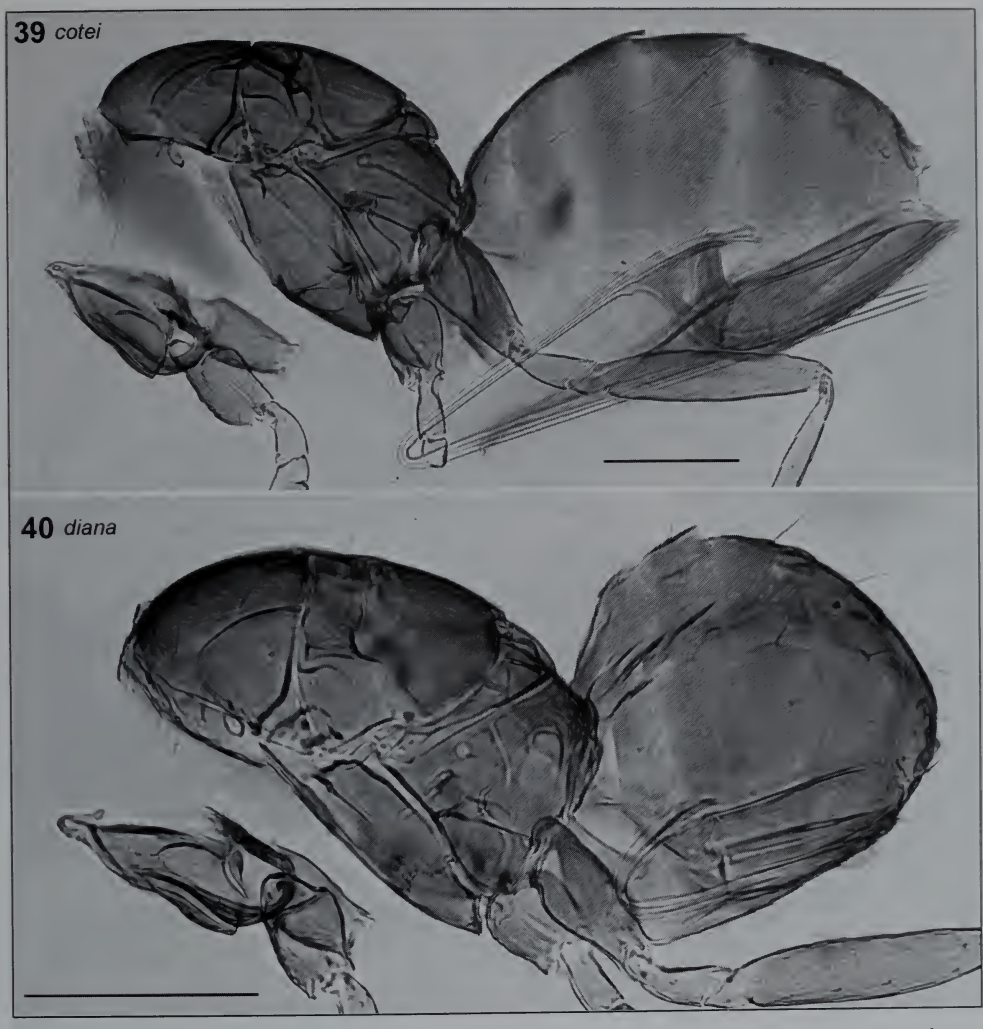
FIGURES 33, 34. *Anaphes*, hind tarsi. 33, *calendrae*, paratype; 34, *luna*, holotype. Scale bars = 0.1mm



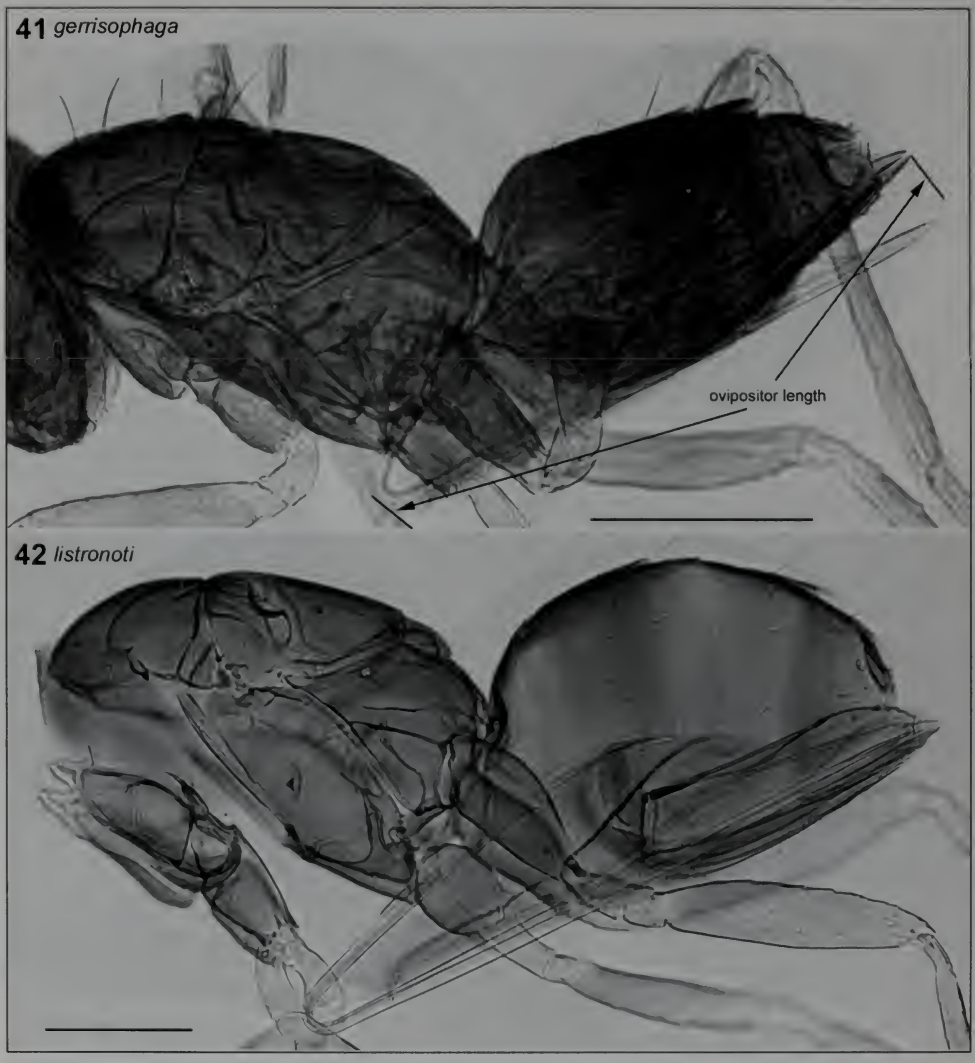
FIGURES 35, 36. Mesosoma + metasoma, lateral view. 35. *brunneus*, holotype; 36, *calendrae*, ex. *Sphenopterus venatus vestitum*, USA: FL, Ft. Lauderdale, vii.1968, H. Nakao & R. Suyukawa. Scale bars = 0.1mm



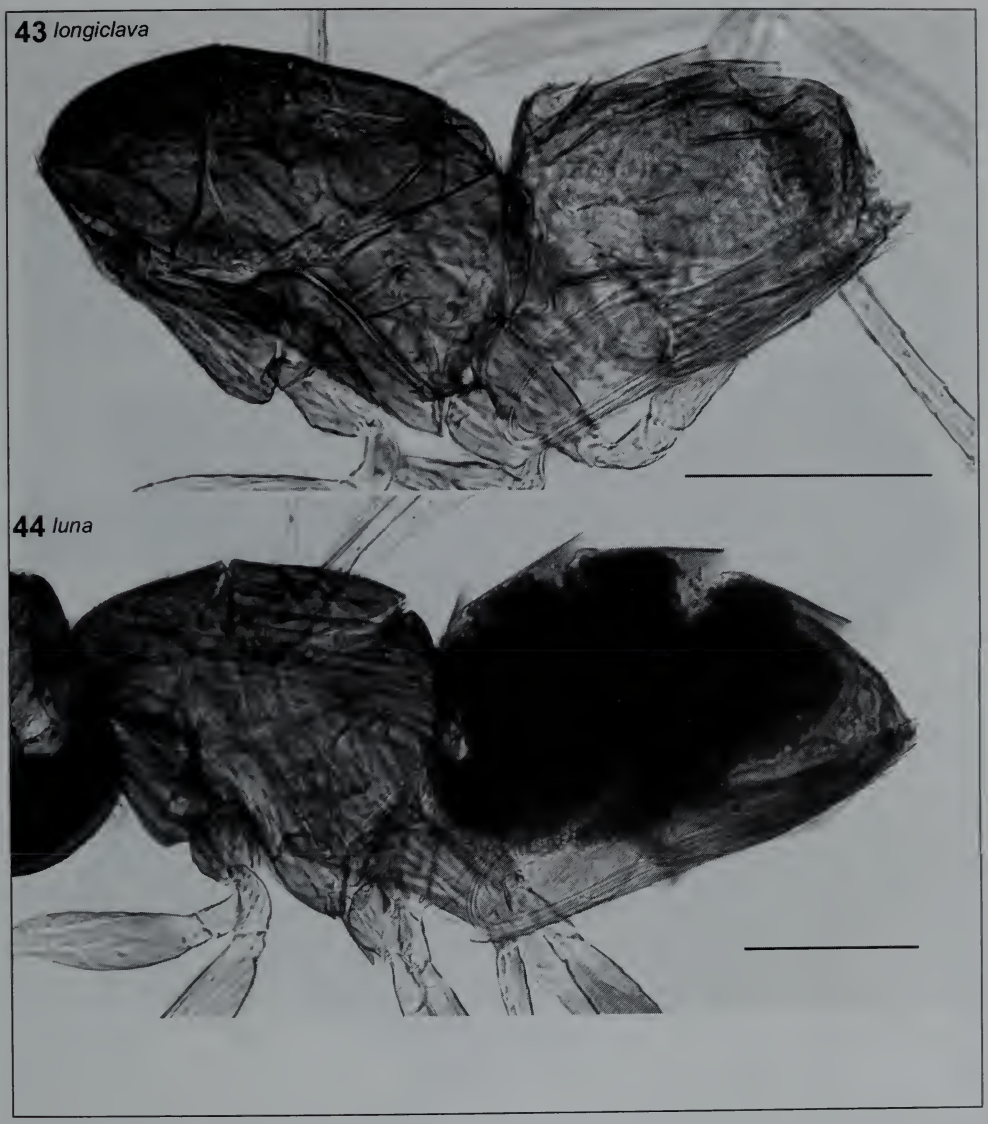
FIGURES 37, 38. Mesosoma + metasoma, lateral view. 37, *confertus*, USA: AZ, 12 mi. N. Sierra Vista, Ramsey Canyon. 10.vi.1987, B.V. Brown; 38, *conotracheli*, CANADA: QC, Ste. Clotilde, 1-23.vii.1990, lab. reared ex. *Listronotus oregonensis*. Scale bars = 0.1mm



FIGURES 39, 40. Mesosoma + metasoma, lateral view. 39, *cotei*, holotype; 40, *diana*, bisexual form, FRANCE: Hérault, St.-Gély-du-Fesc, iii.1984, J.P. Aeschlimann, ex *Sitona* sp. Scale bars = 0.1mm

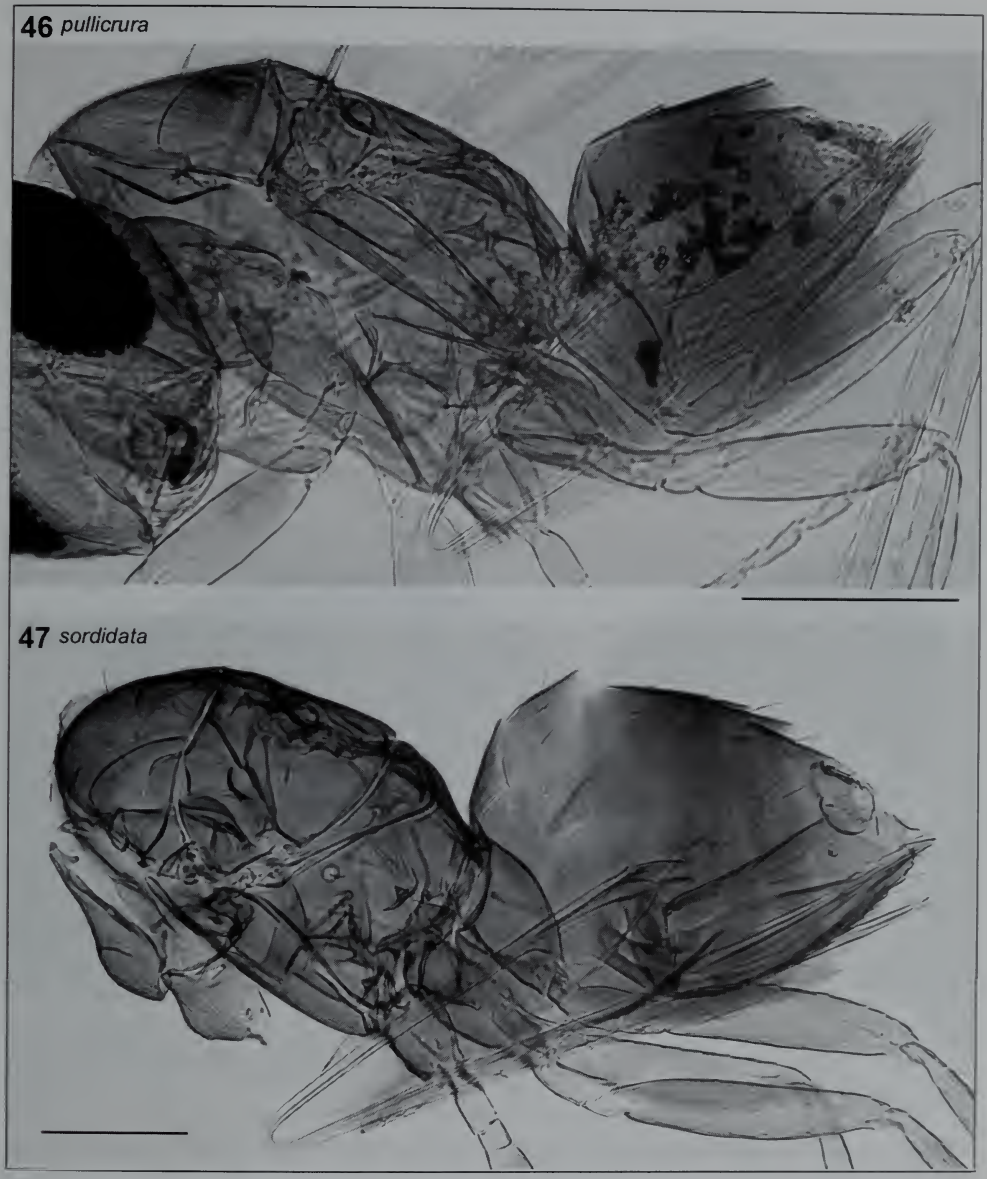


FIGURES 41, 42. Mesosoma + metasoma, lateral view. 41, *gerrisophagus*, CANADA: ON, Oxford Mills, 13-20.vii.1973, L. Masner; 42, *listronoti*, holotype. Scale bars = 0.1mm

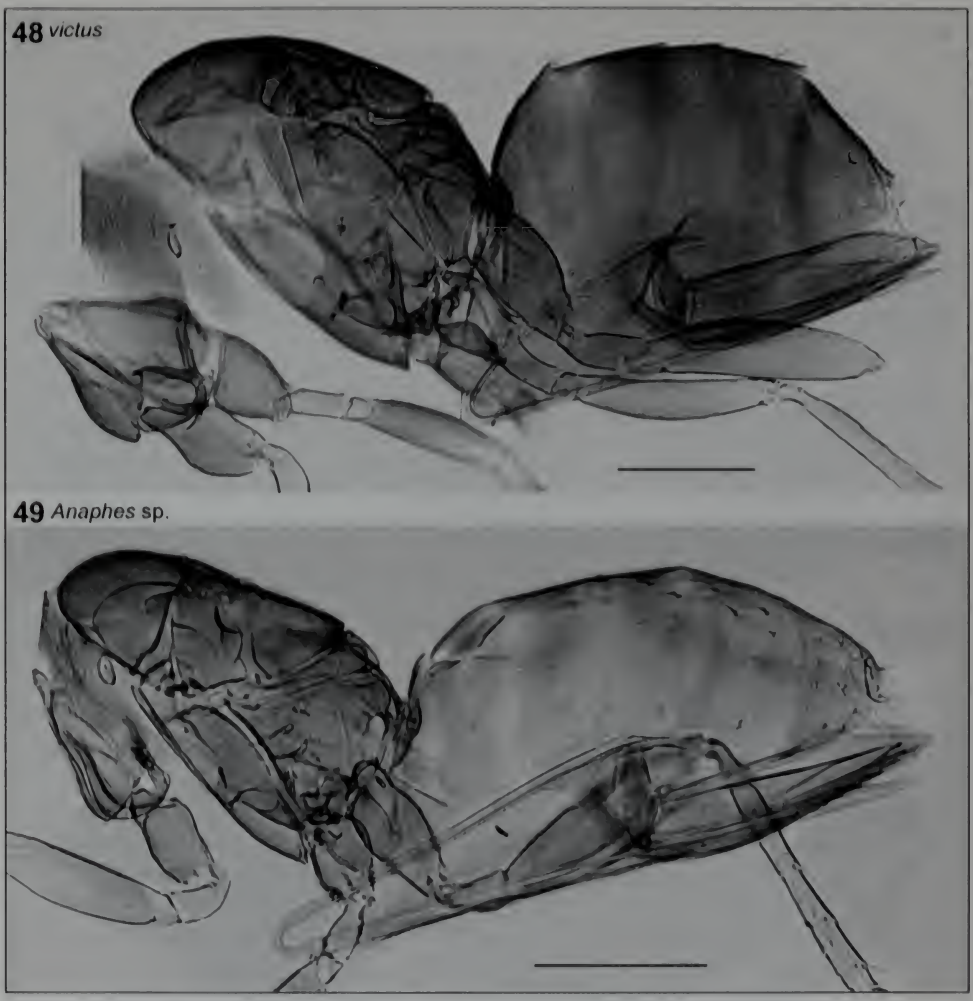


FIGURES 43, 44. Mesosoma + metasoma, lateral view. 43, *longiclava*, holotype. 44, *luna*, USA: UT, Salt Lake City, 12.vi.1911, T.H. Parks, ex. *Hypera* "reared through Utah eggs." Scale bars = 0.1mm

FIGURES 45. Entire body (before remounting) of *pallipes*, holotype. Scale bars = 0.1mm



FIGURES 46, 47. Mesosoma + metasoma, lateral view. 46, *pullicrurus*, holotype; 47, *sordidatus*, USA: IL, Marion Co., Centralia, emerg. 29.vi.1992, ex. *Tyloderma foveolatum* on *Oenothera biennis*, S. Côté. Scale bars = 0.1mm



FIGURES 48, 49. Mesosoma + metasoma, lateral view. 48, *victus*, holotype; *Anaphes* sp. not *luna*, WI, Madison, spring, 1985, lab. culture ex. *Hypera postica*, W. Gould. Scale bars = 0.1mm

ONTARIO BEES OF TRIBE EPEOLINI: *EPEOLUS* LATREILLE AND *TRIEPEOLUS* ROBERTSON (HYMENOPTERA: APIDAE, NOMADINAE)

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Abstract *J. ent. Soc. Ont.* 135: 87–99

Seventeen species of Epeolini (Nomadinae) are reported from Ontario, including ten species of *Epeolus* Latreille and seven of *Triepeolus* Robertson. A key to the species is presented, along with descriptions, notes about their phenology and locality records. Species recorded from Ontario first time are ***Epeolus autumnalis* Robertson, *E. bifasciatus* Cresson, ***E. ilicis* Mitchell, *E. interruptus* Robertson, ***E. lanhami* Mitchell, *E. minimus* (Robertson), *Triepeolus cressonii* (Robertson), ***T. junctus* Mitchell, ***T. lunatus* (Say), ***T. michiganensis* Mitchell, *T. pectoralis* (Robertson), ***T. remigatus* (Fabricius) species marked with (**) are also first recorded for Canada.

Introduction

Little is known about Epeolini in Ontario, and until now only five species belonging to this tribe have been reported from the province, four of which are in the genus *Epeolus* (MacKay and Knerer 1979; Mitchell 1962). Examination by the author of bee specimens in several Ontario insect collections showed that at least 17 species of Epeolini occur in Ontario, including seven species of *Triepeolus*, and ten species of *Epeolus*. The earlier recorded presence of *E. banksi* Cockerell, was not confirmed by our studies (MacKay and Knerer 1979). The purpose of this report is to allow accurate recognition of the species of Epeolini in Ontario, and to update information regarding their presence in the province.

Materials and methods

A total of 425 specimens of Epeolini were examined from the Entomology collections at the Royal Ontario Museum (ROME), University of Guelph (DEBU), and Canadian National Collection of Insects (CNCI) as well as types and comparative material from the California Academy of Sciences (CASC), Illinois Natural History Survey (INHS), and Academy of Natural Science, Philadelphia (ANSP). Morphological characteristics, flight period, and species distribution data for Ontario are based on specimens from these collections. Morphological terms used in this paper are defined and illustrated in Michener (1944, 2000) and Rightmyer (2004). Abbreviations used are as follows: F – flagellar segment, T – metasomal tergum, S – metasomal sternum. Species new for Ontario are designated by an asterisk; those with two asterisks are first recorded for Canada.

Species identification was done or confirmed using Mitchell (1962). Morphological characteristics for the generic diagnosis follow Rightmyer (2004). Overall geographical distributions of the species in North America are based on Hurd (1979) and Mitchell (1962).

The distributional data are presented in the form of an annotated list and are illustrated with maps. The locality records in the annotated lists are arranged from north to south according to Ontario's primary administrative divisions (the administrative categories, i.e., "county', "district", etc, are omitted).

Tribe Epeolini

Ontario bees of the tribe Epeolini are distinguished from other bees of the provincial fauna as follows: metasoma conical; all tagmata with white hair pattern; head, mesosoma, apex of metasoma, and partly legs often orange; axillae produced posteriorly to a point or rounded; marginal cell rounded apically and away from wing margin; female S6 retracted, emarginate medially, and with posteriorly directed lateral processes. With respect to the two genera found in Ontario, males and females of the same species have similar body hair patterns, microsculpture, and pubescence; males tend to have denser pubescence on the face and mesepisternum. All of the species are cleptoparasitic on other bees.

Genus *Epeolus* Latreille

Body length 6-10 mm. Maxillary palpus usually two-segmented, rarely three-segmented. Mandibles may have a subapical tooth. Antennal pedicel of the male is usually mostly exposed. S7 of the male usually lacking median emargination on distal margin, with lateral lobes above interlobal area, and with apical setae mostly dorsal, on surface leading from lateral lobe. Base of gonostylus with dorsal protuberance. T5 of the female with transverse, silvery pseudopygidial area. S6 of the female with processes paddle-shaped, distal margin denticulate.
Parasites on *Colletes* bees (Colletidae).

Key to *Epeolus* species of Ontario

The species descriptions, following dash in couplets, involve only the most important characteristics for the recognition of the species treated in Ontario.

1. Forewing with two submarginal cells. — Eye width 1.7 times genal area. Scutum with antero-lateral patches of dense, white hairs. Mesepisternum with punctures deep, less than pit diameter apart. Axillae reaching middle line of scutellum. Middle and hind spurs dark. T1 and T2 with apical band widely interrupted. T3 and T4 with bands narrowed or interrupted medially and on sides. ♀ T5 widely truncate, with thin, white hair patches laterally; pseudopygidial area 4 times as wide as long. ♂ pygidial plate narrowly angulate apically. Body length 6-8 mm. ON: VI-VII. — ME, PA, MI. .... ***E. lanhami*** Mitchell
- Forewing with three submarginal cells..... 2
2. Metasoma with two hair bands. Scutum without antero-median, white hair stripes or patch. — Eye 4 times as wide as genal area. Pronotum and tergal bands with hairs dense, scaly. Mesepisternum shiny, bare, with punctures more than diameter apart to confluent. Middle and hind spurs dark. ♀ T5 broadly truncate, with pseudopygidial area 4-5 times as wide as long. ♂ pygidial plate truncate. Body length 7-9 mm. ON: VI-VIII. — New England states to MN, south to CO, NM, TX, FL. .... ***E. bifasciatus*** Cresson
- Metasoma with more than two bands. Scutum with antero-median, white hair stripes or patch..... 3

3. Scutum with antero-median, horse-shoe shape white hair patch. — Eye 2 (♂) or 2.5 (♀) times as wide as genal area. Mesepisternum with lower part shiny, with a few flat interspaces. Axillae not attaining posterior margin of scutellum. T1 with central dark space subtriangular; T1 and T2 with hair bands interrupted medially, enlarged laterally. T3-T5 with hair bands complete. Spurs orange. ♀ pseudopygidial area 2.5 times as wide as long. ♂ pygidial plate widely rounded. Body length 6-8 mm. ON: VI-VIII. – QC, NS, NY, MI, IN..... ***E. canadensis*** Mitchell
- Scutum with two anterior white hair lines..... 4
4. Axillae usually with tips attaining posterior margin of scutellum..... 5
- Axillae shorter, not attaining posterior margin of scutellum. 6
5. ♀ pseudopygidial area 2.5-3 times as wide as long. ♂ pygidial plate black or orange, wide, slightly narrowed apically, with central emargination; mesepisternum partly bare; sterna shiny. — Eye 2.5 (♀) - 4 (♂) times as wide as genal area. Axillae flat. Mesepisternum on lower part with a few flat interspaces. T1 anteriorly with lateral, white hair triangles; central, black space wide, white hairs sometimes reduced laterally, basal and apical hair bands narrowed medially. T2-T5 with bands complete. Middle and hind spurs dark. Body length 7-10 mm. ON: VII-IX. — NS to MN, south to TX, FL. ..... ***E. scutellaris*** Say
- ♀ pseudopygidial area 1.5-2 times as wide as long. ♂ pygidial plate orange, narrowly acute apically; mesepisternum entirely with dense, white hairs; sterna with white pile.— Eye 3-3.5 times as wide as genal area. Axillae flat, with outer margin elevated. Mesepisternum on lower part with interspaces between punctures flat. Tergal hair bands complete. T1 anteriorly completely covered with dense, white pile. T1-T3 or T1 and T2 with hair bands narrowed medially, sometimes narrowly interrupted. Middle and hind spurs dark. Body length 7-8 mm. ON: VIII-IX. — ME to CA, FL, TX. ..... ***E. pusillus*** Cresson
6. T1 with median dark space rectangular, lateral white hair stripes wide. — Eye 2-2.5 times as wide as genal area. Mesepisternum on lower part with linear interspaces between punctures. Scutum laterally with white pile. T1 anteriorly with white pile, apical hair bands interrupted medially, enlarged laterally. Spurs orange. S2 centrally with thick white pile. ♀ pseudopygidial area 3 times as wide as long. ♂ pygidial plate round apically, orange. Body length 7-8 mm. ON: VII-VIII. — WI, MI, IL, to CA, CO. .... ***E. minimus*** (Robertson)
- T1 with median dark space stretched from side to side, lateral angles narrowly rounded 7
7. Mesepisternum on lower part with interspaces between punctures linear. — Eye twice as wide as genal area. ♂ clypeus bare, with median, longitudinal ridge. Scutum with extended, erect, white hairs on dark surface. T1 with both hair bands interrupted. T2-T6 with hair bands complete, sometimes, T2 and T3 with bands interrupted. T2 with lateral, thin, white hair patches. Body length 7-8 mm. ON: VII. — MA, to TN, GA. ..... ***E. ilicis*** Mitchell
- Mesepisternum on lower part with interspaces between punctures flat. 8
8. Scutum and scutellum shiny, with punctures more than diameter apart to confluent. Mesepisternum shiny, with lower part punctures more than diameter apart. — Eye 3-3.5 times as wide as genal area. Pronotal lobes partly orange. Axillae with narrow apex turned inside. Middle and hind spurs dark. T1-T5 with hair bands interrupted. Terga and sterna shiny. Sterna with dense, white, scaly hairs. ♀ pseudopygidial area as long as wide. ♂

pygidial plate round apically. Body length 7-10 mm. ON: VII-VIII. — New England states, to IL, south to GA. ..... ***E. lectoides*** Robertson

- Scutum and scutellum shagreened, or with interspaces between punctures linear. Mesepisternum on lower part with punctures diameter or less apart..... 9

9. T1-T4 with white, hair bands interrupted, medially and laterally enlarged. — Eye 2(♀) -3 (♂) times as wide as genal area. Axillae as long as wide basally. T2 with thin, gray hairs laterally. ♀ pseudopygidial area 5 times as wide as long. Body length 6.5-8 mm. ON: VII. — NJ, to GA, west to CA, CO, TX..... ***E. interruptus*** Robertson

- T1 with white hair band interrupted, T2 and T3 with bands narrowed medially, enlarged laterally. — Eye 1.5 times as wide as genal area. Axillae flat, with outer margin elevated. T1 anteriorly with white hair triangles. ♀ pseudopygidial area twice as wide as long, T5 hair band interrupted. ♂ pygidial plate widely round apically. Body length 9-10 mm. ON: IX. — ME, to MN, south to NC. ..... ***E. autumnalis*** Robertson

Annotated list of Ontario *Epeolus* Latreille

The species are listed in alphabetical order.

The abbreviations of the names of the collectors are as follows: AR (W. Attwater), AT (C. Atwood), BG (N. Bigelow), BK (M. Buck), BR (K. Barber), CL (S. Clark), ED (C. Edwards), KL (L. Kelton), KN (G. Knerer), LM (R. Lambert), MF (R. MacFarlane), MK (P. MacKay), MN (J. Martin), PA (S. Paiero), PG (D. Pengelly), SL (F. Sladen).

1. **_E. autumnalis_ Robertson

Frontenac: Kingston, 5.IX.1987, 2♀, C. Shilton (DEBU). **Northumberland:** Alderville, First Nations, 1.IX.2001, 2♂, PA (DEBU); Murray Hills, 1.IX.2002, 4♂, PA (DEBU). **Dufferin:** Mono Cliffs P.P., 31.VIII.2002, 2♂, BK (DEBU). **Essex:** Windsor, Ojibway Prairie, 22.IX.2001, ♀, S. Marshall; 12-13.IX.2002, 7♀, 8♂, BK, PA (DEBU).

Reviewed materials from other regions. Lectotype, ♀, Charles Robertson Collection, W.E. LaBerge det. 1979 (INHS). Lectoallotype, ♂, Charles Robertson Collection, W.E. LaBerge det. 1979 (INHS). Figure 1.

2. *_E. bifasciatus_ Cresson

Lanark: Lanark, 1.VIII.1976, ♂, S. Marshall (DEBU). **Carleton:** Ottawa, 5.VIII.1955, ♂, P. Taschereau; 29.VII.1947, ♀, W. Mason (CNCI); 22.VI.1977, ♀, Roughley (DEBU). **Simcoe:** Midland, 10.VIII.1974, ♀, J. Huber (DEBU). **Bruce:** Hepworth, 26.VII.1997, ♂, S. Marshall (DEBU). **York:** Toronto, 4.VIII.1905, ♂, Cosens Coll. (ROME). **Wentworth:** Freelton, 15.VII.1972, ♀, B. Beam (DEBU). **Lincoln:** Grimsby, 29.VII.1894, ♀ (CNCI). **Lambton:** Walpole Isl., 11.VII.1977, ♂, AR (DEBU). **Kent:** Rondeau Park, 17.VII.1962, 3♀, 2♂, CL (CNCI); 29.VI.2002, 4♀, ♂. BK (DEBU). **Essex:** Pelee Isl., 8.VII.1965, ♀, J. Riotte (ROME); Point Pelee, 29.VII.1920, ♂, BG (ROME); 10.VII. 1979, ♂, AR (DEBU). Figure 1.

Reviewed materials from other regions. Paralectotype, ♀, R.L. Brumley det. 1965 (ANSP); NJ, Cape May, July 19.1935, ♀, Witmer Stone (ANSP).

3. _E. canadensis_ Mitchell

Carleton: Ottawa, 28.VI.1967, ♂, Heming; 3♂ (DEBU); 22.VIII.1958, ♂, KL; 29.VII.1947, ♂, W. Mason; 28.VI.1914, ♂, SL; 7-11,VII.1913, 9♀, 11♂, SL (CNCI). **Hastings:** 3.VII.1896, 2♂,

Evans; Belleville, 14.VII. 1951, ♀, MN (CNCI). **Prince Edward:** Picton, Smith's Bay, 1.VII.1970, ♂, J. MacAlpine (CNCI). **Durham:** Kendal, 29.VII. 1961, ♀, AR (DEBU). **Bruce:** Dyers Bay, 19-29.VII.1953, 2♂, PG (CNCI). **York:** Toronto, 18.VII.1888, ♀ (CNCI). **Peel:** Forks of the Credit, 28.VI.1965, ♂, KN (ROME). **Wellington:** Guelph, 7.VII.1978, ♂, B. Werner (DEBU). **Brant:** Brantford, Railway Prairie, 12.VII.2002, 3♂, PA (DEBU). **Lambton:** Walpole Isl., 13.VII.1980, ♂, BR (DEBU). **Kent:** Rondeau Park, 27.VI. 1962, ♀, CL (CNCI). **Essex:** Windsor, Ojibway Prairie, 7.VIII.2001, ♀, PA (DEBU); Point Pelee, 26.VII.1979 ♀, AT; 18.VII. 1978, ♂, BR (DEBU). Figure 2.

4. *E. ilicis* Mitchell**

Bruce: Dyers Bay, 31.VII.1953, ♂, PG (DEBU). **Wellington:** Guelph, 30.VIII.1978, 2♂, H. Farrell (DEBU). Figure 1.

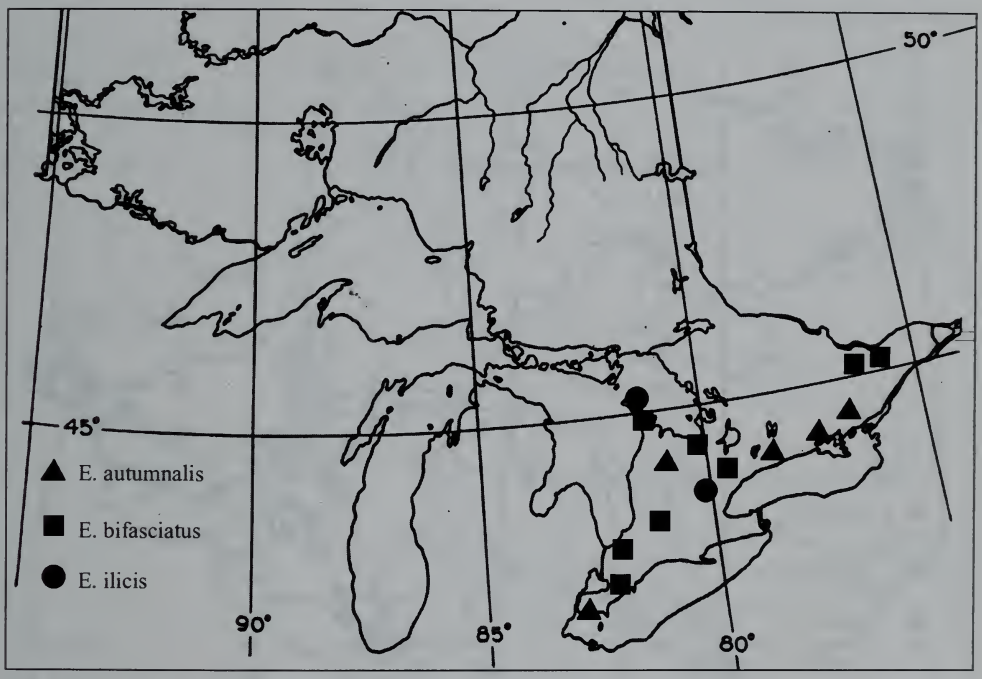

FIGURE 1. Ontario collection localities of *Epeolus*: *E. autumnalis*, *E. bifasciatus*, *E. ilicis*.

5. *_E. interruptus_ Robertson

Carleton: Ottawa, 29.VII.1947, ♀, W. Mason (CNCI). **Bruce:** Hepworth, 4.VII.1954, ♀, PG (DEBU). **Wellington:** Guelph, 20.VII.1973, ♀, AR (DEBU). Figure 2.

Reviewed materials from other regions. Holotype, ♀, Charles Robertson collection (INHS). USA: CA, Colton, 26-28.V.1917, ♂, E. P. VanDuzze, R.L. Brumley det. 1965 (CASC); CO, Boulder, 20.VII.1908, ♂, S. A. Rohwer (CASC); VA, Norfolk, June 12, 1895, ♀, R.L. Brumley det. 1965 (ANSP).

6. ** *E. lanhami* Mitchell

Rainy River: Rainy River, 24.VI.1960, 4♀, 2♂, CL (CNCI). **Thunder Bay:** Black Sturgeon Lake, 10.VII. 1964, ♀ (CNCI). **Sudbury:** 2♂ (CNCI). Figure 3.

Reviewed materials from other regions. QC: Sully, 22.VI.1916, ♂, SL (CNCI); Lac Mirabelle, off James Bay Rte. Km 323, 51°52'N, 77°24'W, sandy area, 16.VII.2001, 3♀, BK (DEBU).

7. *E. lectoides* Robertson

Bruce: Hepworth, 4.VII.1954, ♀, PG (DEBU). **Wellington:** Gueph, 20.VII.1977, ♀, AR (DEBU). **Lambton:** Port Franks, 12.VII.1996, ♂, Skevington (DEBU). **Kent:** Rondeau Park, 8.VII. 1983, ♀, ♂, Gadovski (DEBU). **Essex:** Point Pelee, 13.VII-8.VIII.1920, 3♀, 5♂, BG (ROME); 4.VIII.1981, 2♀, Aiudi; 10.VII. 1979, 2♂, AR; 20.VII.1978, ♀, BR (DEBU). Figure 2.

Reviewed materials from other regions. Holotype, ♀, Charles Robertson collection (INHS). USA: NC, Cumberland, Fort Bragg, 16.VIII.1967, ♀, ♂, 23-25.VIII.1967, ♀, ♂, H. D. Birchim, G. Bohart det. (CASC).

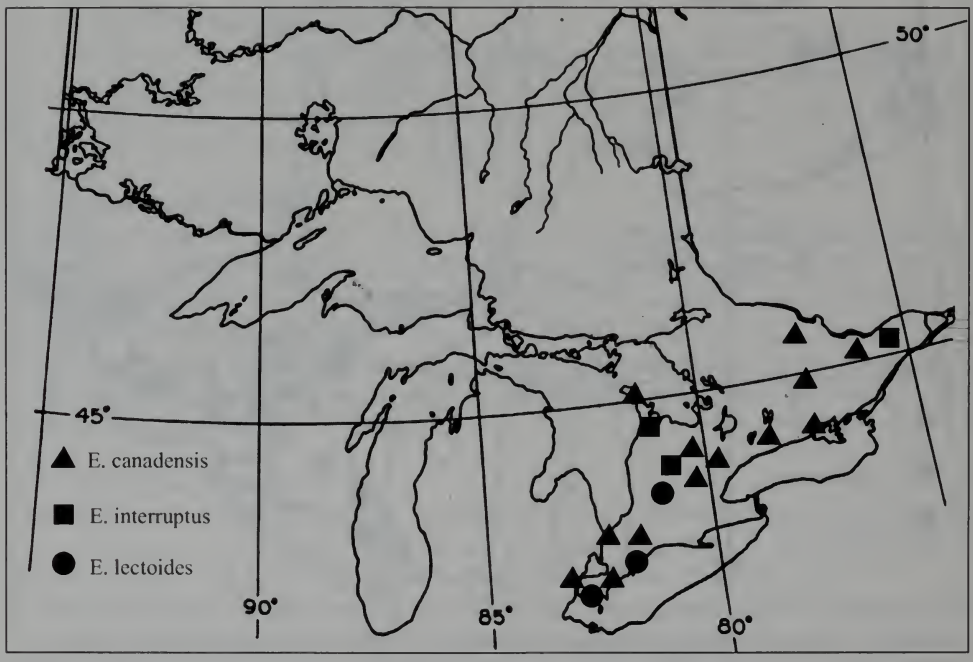

FIGURE 2. Ontario collection localities of *Epeolus*: *E. canadensis*, *E. interruptus*, *E. lectoides*.

8. **E. minimus* (Robertson)

Rainy River: Rainy River, 5.VII-3.VIII.1960, 2♀, CL; 17.VIII.1924, ♂, J. Brimley (CNCI). **York:** Leaside, 7.VII.1959, ♀, *Medicago* (ROME). **Bruce:** Dyers Bay, 20.VII-19.VIII.1953, ♀, 4♂, PG; 9-15.VII.1952, 4♀, PG, *Clover* (CNCI); 2.VII.1957, ♂, PG; 17-22.VII.1956, 2♀, PG; 8-25.VII.1954, 5♀, 8♂, PG; 16.VII.1953, ♀, PG (DEBU). **Brant:** Brantford, 24.VIII.2001, ♂, PA (DEBU); Railway Prairie, 12.VII.2002, ♀, PA (DEBU). Figure 3.

Reviewed materials from other regions. Paratype, ♂, R.L. Brumley det., 1965. Canada: BC, Vernon, 19.VII.1922, ♀, H.B. Leech, B.L. Brumley det. 1965 (CASC). USA: CA, Modoc Co, Davis Cr., 13.VII.1922, ♂, C.L. Fox, B.L. Brumley det. 1965 (CASC); CA, Ruby Lake, NW, Inyo Co, 11500 ft, 13.VIII.1957, ♂, C.D. MacNeill, B.L. Brumley det.1965 (CASC); WA, Olympia, 2.VII.1896, ♀, B.L. Brumley det. 1965 (CASC); WY, W. Yellowstone, 14.VI.1930, ♀, VanDyke, B.L. Brumley det. 1965 (CASC); NV, ♀, R.L. Brumley det. 1965 (ANSP).

9. *E. pusillus* Cresson

Carleton: HWY 16, 44° 47′12′′N, 75° 30′38′′W, 23-30.VIII.1994, ♀, L. Masner (CNCI); Ottawa, 25.VIII.1954, ♂, W. Mason (CNCI). **Prescott:** Van Kleek Hill, 1.IX.1974, 2♀, J. Huber (DEBU). **Peterborough:** Peterborough, 18.VIII.1975, ♂, F. Quan (ROME). **Bruce:** Inverhuron, 2.IX.1960, 2♀, ♂, PG (DEBU). **Peel:** Forks of the Credit, 25.VII-27.VIII.1968, 6♀, 5♂ .MK (ROME); Peel, 19.IX.1992, ♂, C. Darling (ROME). **Welland:** Port Colbourne, 17.IX.1972, ♀, Beam (DEBU). **Brant:** Brantford, 24.VIII.2001, ♂, PA (DEBU). **Lambton:** Grand Band, 28.VIII.1936, ♂, AT (CNCI). **Essex:** Windsor, Ojibway Prairie, 13.IX.2002, 13 ♀, 5♂, PA (DEBU); 26.VIII.2002, 8♂, BK, PA (DEBU). Figure 3.

Reviewed materials from other regions. USA: TX, Lee Co, Fedor, 26.IV.1909, ♀, B.L. Brumley det. 1965 (CASC); FL, Tampa, 2.V.1908, ♂, VanDuzee, B.L. Brumley det. 1965 (CASC); NJ, Clementon, 8.7.1892, ♂, R.L. Brumley det. 1965 (ANSP).

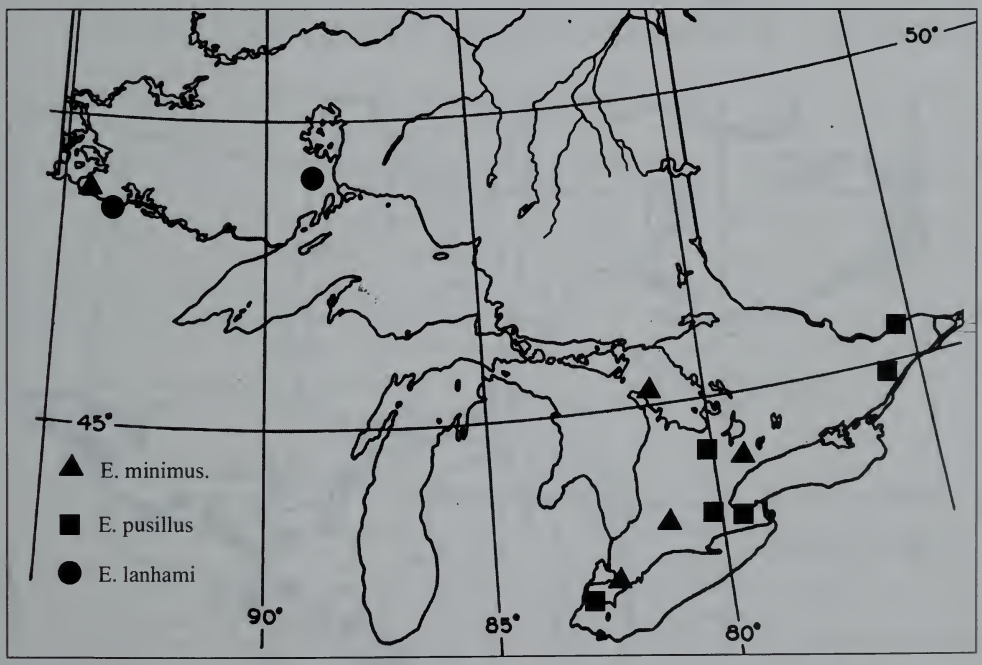

FIGURE 3. Ontario collection localities of *Epeolus*: *E. minimus*, *E. pusillus*, *E. lanhami*.

10. *E. scutellaris* Say

Rainy River: Lake of the Woods, Harris Hill, 4.VIII.1960, ♂, KL, Whitney (CNCI). **Lanark:** Almonte, 2-7.IX.1986, ♀, H. Goulet (CNCI). **Carleton:** Ottawa, 11.VIII.1973, 4♀, J. Huber (DEBU); 20-25.VIII. 1954, ♀, 2♂, W. Mason; 30.VII.1913, ♂, SL (CNCI); HWY 16, 44° 47′12″, 75° 30′38″, 23.VIII.-29.IX.1994, 7♀, L. Masner (CNCI). **Grenville:** Spencerville, 28.VIII-14.IX.1939, 2♀, G. Hammond; 20.VIII.1938, ♀, G. Hammond (CNCI). **Hastings:** Johnstown, 5.IX.1972, ♀, MF (DEBU). **Haliburton:** Algonquin P.P., 45° 51′, 77° 42′45″, 18.VIII.2002, 4♀, ♂, BK (DEBU). **Peterborough:** Bobcaygeon, 18.VIII.1975, ♂, F. Quan (ROME). **Northumberland:** Murray Hills, 1.IX.2002, ♂, PA (DEBU); Brighton, 2.IX.1954, ♂, MN (CNCI). **Durham:** Burketon, 30.VIII.1954, ♀, C. Miller (CNCI); Orono, 3.IX.1925, ♀, BG (ROME). **Simcoe:** Spring Water P.P., 2.IX.2002, ♀, BK (DEBU). **Bruce:** Hepworth, 23.VIII.1981, ♀, BR; 31.VII.1975, ♂, Jaspers (DEBU); Sauble Beach, 17.IX.1972, ♀, Beam (DEBU); Dyers Bay, 12-27.VIII.1953, 5♀, ♂, PG (DEBU). **Peel:** Forks of the Credit, 18-27.VIII.1969, 3♀, MK; 8-27.VIII.1968, 2♂, MK (ROME); Peel, 19.IX.1992, ♂, C. Darling (ROME). **Wellington:** Guelph, 25.VIII.1997, ♀, S. Marshall; 18.VIII. 1978, ♀, Farrell; 18.VIII. 1976, ♀, Stewarts; 14.IX. 1975, ♀, Barlow; 17.VIII. 1973, ♀, MF; 5-10.IX. 1972, 5♀, MF; 20.IX. 1970, ♀, Akey (DEBU). **Waterloo:** Cambridge, 9.VIII. 1981, ♀, C. Bolter (DEBU). **Welland:** Port Colbourne, 27.VIII.1993, 2♀, D. Caloren (DEBU). **Brant:** Brantford, 24.VIII.2001, 3 ♀, 2♂, PA (DEBU). **Haldimand:** Dunnville, 3.VIII.1954, ♂, C. Miller (CNCI). **Middlesex:** Komoka Feed Mill, 11.IX.2001, ♀, PA (DEBU). **Norfolk:** Normandale, 4.IX.1954, ♀, C. Miller (CNCI); St. Williams, 24.VIII.2001, ♀, 2♂, BK (DEBU). **Lambton:** Grand Band, 20.VIII.1936, ♂, A. Wood (CNCI). **Essex:** Windsor, Ojibway Prairie, 11-22.IX.2001, 2♀; 26.VIII.2002, 3♂; 13.IX.2002, 3♀, ♂, PA (DEBU); Point Pelee, 30.VII.1978, ♀, AR (DEBU). Figure 4.

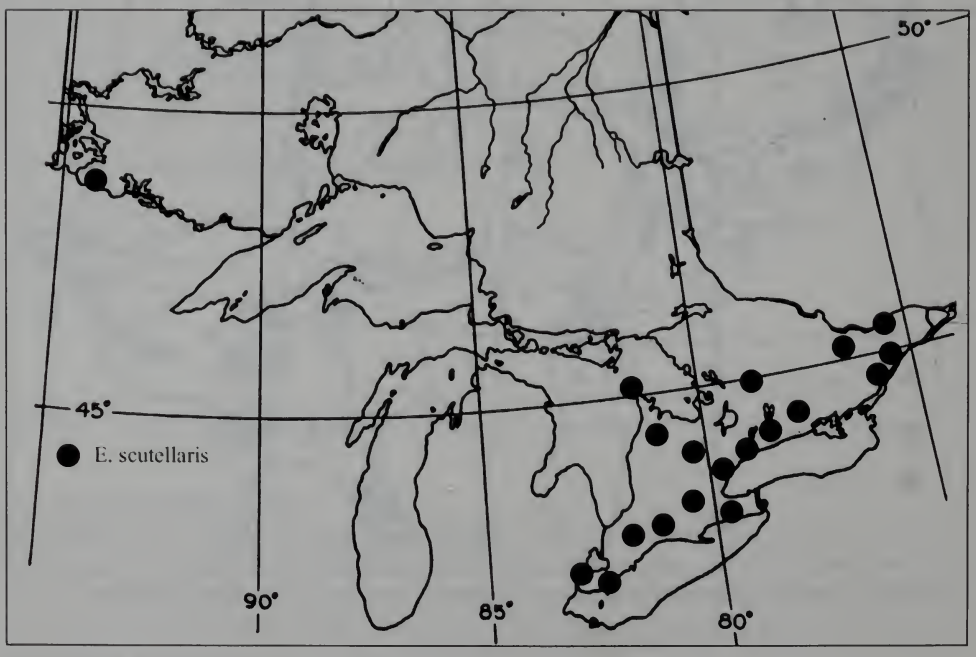

FIGURE 4. Ontario collection localities of *Epeolus*: *E. scutellaris*.

Reviewed materials from other regions. USA: MA, Boston, 5.IX.1914, 2♀, F.X. Williams, B.L. Brumley det. 1965 (CASC); MA, Forest Hills, 30.VIII.1913, ♂, F.X. Williams, B.L. Brumley det. 1965 (CASC); VA, Falls Church, 4.IX., ♀, G. Bohart det. (CASC); NM, San Juan Co, 33 mi S of Shiprock, 14.IX.1970, ♂, sunflower, P.S. Bartholomew, G. Bohart det.(CASC); NH, Nelson, 8-11.07, ♂, R.L. Brumley det. 1965 (ANSP).

Genus *Triepeolus* Robertson

Commonly larger than *Epeolus*, body length 8-14 mm. Maxillary palpus usually three-segmented, if two-segmented, then the distal segment is elongate. Mandibles lacking distinct preapical tooth. Antennal pedicel usually set into scape. Pygidial plate usually with median constriction, often apically differentiated into distinct, down-turned, posterior surface. S7 usually with median emargination on distal margin, with lateral lobes below interlobal area, and apical setae mostly ventral, forming distinct pocket near lateral apical lobe. Gonostylus without basal protuberance. T5 of the female usually with elongate, dark, not transverse and silvery, pseudopygidial area. S6 of the female with greatly reduced, transverse disc; narrow, latero-apical processes with several coarse, curved bristles apically.

In Ontario may parasitize on *Melissodes*, *Peponapis*, *Svastra*, *Tetralonia* and *Anthophora*.

Key to *Triepeolus* species of Ontario

1. T1 with central black area round or triangular, narrower or equal in width to lateral, white hair spaces. 2
- T1 with central black area wide, rectangular or narrowed laterally, wider than lateral white hair spaces. 3
2. T1 with central black area round, small. Scutum with anterior, wide, white hair band interrupted medially between longitudinal hair lines. — ♀ clypeus without longitudinal ridge. Eye 2-2.5 times as wide as genal area. T1 and usually T2 with hair bands interrupted medially. T3 and T4 with hair bands complete. Body length 14 mm. ON: VII. — NJ, west to MN, CO, south to CA, TX, FL. ..... ***T. remigatus*** (Fabricius)
- T1 with central black area subtriangular, with acute lateral angles. Scutum without anterior, white hair band, with pair of longitudinal, white hair lines anteriorly. — ♀ clypeus with longitudinal, impunctate ridge. Eye 2.5 (♂)-3 (♀) times as wide as genal area. T1 and T2 with hair bands interrupted medially. T3 and T4 with white hair bands complete or narrowly interrupted. ♀ T5 with white hair band interrupted. Body length 10-11 mm. ON: VI-VIII. — New England states to MN, south to FL, CO, NM. ..... ***T. lunatus*** (Say)
3. Axillae exceeding scutellar apex. — ♂ face, labrum, clypeus, mesepisternum, and mesosoma ventrally with dense, white hairs. Mandibles, pronotal lobes, tegulae, and legs yellow; mid and hind spurs black. Body with yellow hairs dorsally, white on lateral and ventral surfaces. Tergal bands complete. T1 with tomentose pubescence anteriorly. T2 with large lateral tomentose patches. Clypeus and face below antennae with thick, silvery hairs. Mesepisternum with dense, white hairs. Sterna with thin, white tomentum, apically thicker. Body length 8-9 mm. ON: VIII. — NY, NC. ..... ***T. junctus*** Mitchell
- Axillae not attaining scutellar apex. 4
4. Propodeum posteriorly and laterally with long, white hairs. — Eye 3 times as wide as genal area. Mandibles, labrum apically, tegulae, legs, pronotal lobs, and pygidial plate orange. Spurs black. Pronotal lobes and antero-lateral angles of scutum with dense pile.

Mesosoma laterally and ventrally with long, white hairs. T1 with dense, white hairs anteriorly, apical band complete. T2 with lateral, white hair stripes, apical band interrupted. T3 with band medially narrowed or interrupted. S3 with wide, white hair fringe. ♂ with pygidial plate narrow, orange, with marginal, dark red curb; basally, to transversal ridge, shiny, with punctures deep, large; apical part impunctate. ♂ S2 with basi-median, white hair spot. Body length 10 mm. ON: VII-VIII. — CT, MI, NY. .... ***? T. michiganensis*** Mitchell

\- Propodeum mostly bare. 5

5. Mesosoma with dark hairs ventrally. Legs brown. — Mesepisternum on lower part with irregular punctures, more than diameter apart in some places. Body with tomentose pubescence white, thick. Clypeus and labrum with dark hairs. T1 with white pile anteriorly, hair bands interrupted. T2 with hair band complete. Sterna without white hairs. Body length 11-12 mm. ON: VIII-IX. — Southern Canada, New England states, west to WI, south to GA. ..... ***T. donatus*** (Smith)

\- Mesosoma with white hairs ventrally. Legs orange. 6

6. Mesepisternal lower part with punctures much more than a diameter apart, shining, with erect hairs. — Eye 3 times as wide as genal area. Scutal black space with extended, erect, thin setae. T1 and ♀ T5 with hair bands interrupted. Pygidial plate widely round, subtruncate. Body length 9-10 mm. ON: VII-IX. — ME to GA, west to MN, UT..... ..... ***T. pectoralis*** (Robertson)

\- Mesepisternal lower part with punctures less than or equal to a diameter apart, in some places, not distinctly shining, lacking erect hairs. — Eye 4 times as wide as genal area. Scutal black space without erect setae. T1, T2, and ♀ T5 with white hair bands interrupted. Fore and middle spurs light, hind spurs dark. ♂ mesepisternum completely pubescent. Pygidial plate narrowly round apically, with dense, dark hairs basal to transverse ridge. Body length 8-11 mm. ON: VII-VIII. — New England states, to MN, south to TN, NC..... ..... ***T. cressonii*** (Robertson)

Annotated list of Ontario *Triepeolus* Robertson

1. *_T. cressonii_ (Robertson)

Carleton: Ottawa, 20.VIII.1913, ♀, SL; 15.VIII.1913, ♂, SL (CNCI). **Northumberland:** Brighton, 23.VIII.1980, 2♂, Addleby (DEBU). **Bruce:** Dyers Bay, 10.VII.1954, ♂, PG; 31.VII-13.VIII.1953, 3♂, PG (DEBU). **Middlesex:** Komoka, Field Mill Prairie, 27.VII-13.VIII.2001, ♂, PA (DEBU). **Essex:** Windsor, Ojibway, 1-17.VII.2001, ♀, P. Pratti (DEBU). Figure 5.

Reviewed materials from other regions. Lectotype, ♀, Charles Robertson collection, W. E. LaBerge det.1979 (INHS). Lectoallotype, ♂, Charles Robertson collection, W.E. LaBerge det. 1979 (INHS). QC, Mer Bleue, 3.VII1985, ♂, C. Maund (CNCI).

2. _T. donatus_ (Smith)

Sudbury: Noelville, 8.VIII. 1974, 2♀, W. Husby (DEBU). **Carleton:** Ottawa, 15.VIII.1913, ♀, SL (CNCI); ♀ (DEBU). **Haliburton:** Algonquin P. P., 17.VIII, 2002, 4♀, BK (DEBU). **Dufferin:** Orangeville, 19.VIII. 1954, ♀, PG (DEBU). **York:** Toronto, 9.VIII.1898, ♂; 1.IX.1893, ♀; 2.VIII.1888, ♂ (CNCI); 2♀, ♂, W. Brodie (ROME). East Ontario, ♀ (DEBU). Figure 5.

Reviewed materials from other regions. USA, MD, Millington, 8.VI.1891, ♂, E.P. VanDuzee (CASC); NJ, Cape May, 9.12.1932, ♂, Witmer Stone, Sandhouse det. (ANSP).

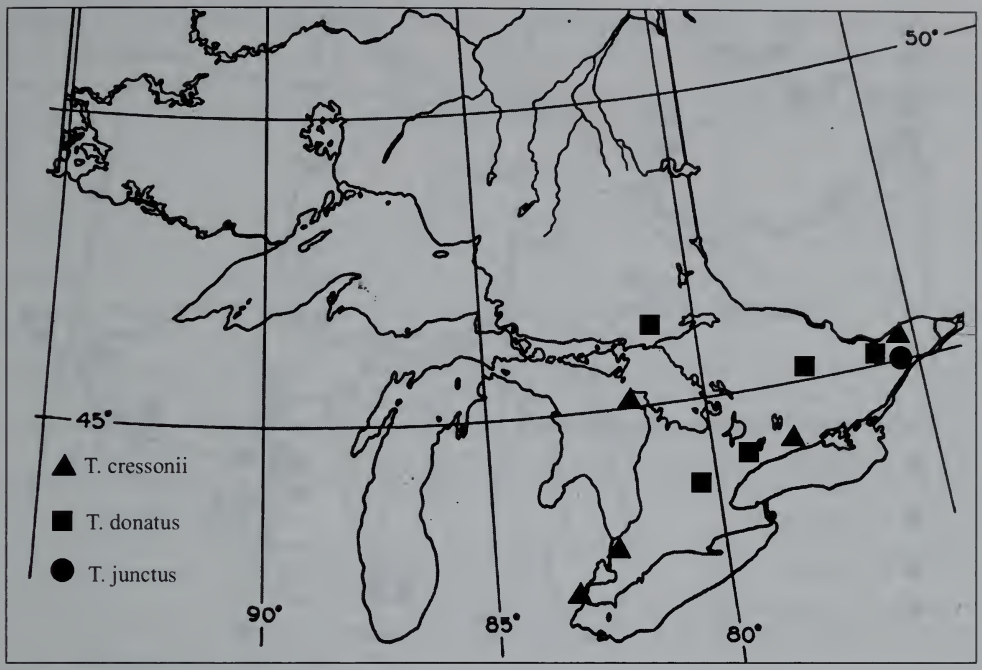

FIGURE 5. Ontario collection localities of *Triepeolus*: *T. cressonii*, *T. donatus*, *T. junctus*.

3. **_T. junctus_ Mitchell
Carleton: Ottawa, 25.VIII.1954, ♂, W. Mason (CNCI). Figure 5.

4. **_T. lunatus_ (Say)
Wellington: Guelph, VI.1960, ♀, Ougun (DEBU). **Essex:** Windsor, Ojibway, 30.VIII.2001, ♂, PA (DEBU). Figure 6.
Reviewed materials from other regions. Lectotype, ♀ (*Epeolus lunatus* concolor Robertson, W.E. LaBerge det, 1979) (INHS). Lectoallotype, ♂, W.E. LaBerge det, 1979 (INHS). USA: AL, Decatur, VIII.1944, ♀ (*Triepeolus concolor* Robertson, G.E. Bohart det), ♀ G.E. Bohart det. (CASC); CO, LaJunta, F. 4762, 37°59'N, 103° 31'W, 4100 fl alt, 12.VIII.1920, ♀(CASC); NJ, Cape May, Aug. 9,1933, ♀, Witmer Stone, det. Sandhouse (ANSP).

5. **? _T. michiganensis_ Mitchell
Sudbury: Noelville, 8.VIII.1974, ♂, R. Nalot (DEBU). **Simcoe:** Awenda P.P., 22.VII.2002, ♂, S. Marshall (DEBU). **York:** Toronto, 16.VII.1893, ♀ (CNCI). **Lincoln:** Grimsby, 12.VIII.1894, ♀ (CNCI). Figure 6.

6. *_T. pectoralis_ (Robertson)
Leeds: Gananoque, 18.VIII.1963, 2♀, ED (DEBU). **Hastings:** Chatterton, 6.VIII.1946, ♀, Howitt (DEBU). **Haliburton:** Dorset P.S., 15.VIII.1961, ♀, KN (ROME); 2.IX.1981, ♀, Aiudi (DEBU). **Bruce:** Dyers Bay, 13-27.VIII.1953, ♀, ♂, PG (DEBU). **Dufferin:** Orangeville, 19.VIII.1954, 2♀, PG (DEBU); Mono Cliffs P.P., 31.VIII.2002, ♀, BK; 13.VIII.2002, ♀, BK

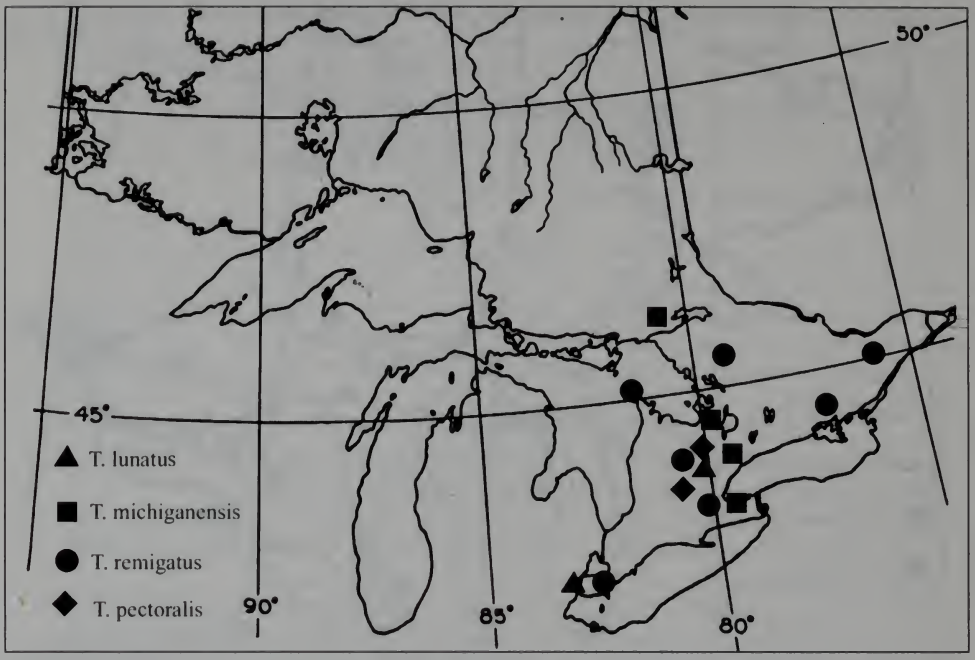

FIGURE 6. Ontario collection localities of *Doeringiella*: *T. lunatus*, *T. michiganensis*, *T. pectoralis*, *T. remigatus*.

(DEBU). **Wellington:** Guelph, VII.1973, ♀, MF (DEBU). **Lincoln:** Vineland, 9.IX.1936, ♂, Ross (DEBU). **Essex:** Windsor, Springarden Road, 12.IX.2002, 2♀, BK, PA (DEBU). **County uncertain:** Effingham, 1.VIII.1954, ♀, C. Miller (CNCI); Harrow, 6.IX.1959, ♀, PG (DEBU). Figure 6.

Reviewed materials from other regions. Lectotype, ♀, Charles Robertson collection (*Epeolus pectoralis* Robertson, W. E. LaBerge det, 1979) (INHS). **Canada:** QC: Cap Rouge, 7.VII.1953, ♂, LM (CNCI). USA: UT, Saltair, 12.VII.1922, ♀, E.P. VanDuzee (CASC); NJ, Blackwood, 9.19.1897, ♀ (ANSP).

7. ***T. remigatus* (Fabricius)**

Wellington: Guelph, VII. 1960, ♂, Quynh (DEBU). **Wentworth:** Ancaster, 23.VII. 1955, ♀ (CNCI). Figure 6.

Reviewed materials from other regions. USA: NJ, Riverton, IX.8.1901, ♀ (ANSP).

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NEW RECORDS OF ORTHOPTERA FROM CANADA AND ONTARIO

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The following ten Orthoptera species are recorded from Canada for the first time, in some cases also representing new records at the generic level: *Melanoplus scudderi scudderi* (Uhler), *M. walshii* Scudder, *Dichromorpha viridis* (Scudder), *Ellipes gurneyi* Günther, *Neoxabea bipunctata* (DeGeer), *Oecanthus latipennis* Riley, *O. laricis* T.J. Walker, *O. exclamationis* Davis, *Meconema thalassinum* (DeGeer), and *Neoconocephalus triops* (Linnaeus). *Oecanthus argentinus* Saussure, previously known from western Canada, is recorded from Ontario for the first time. Some additional records are given for rare species previously known only from one or two Canadian records, and the significance of these new records is discussed. Although these new records were generated by observation and collecting efforts throughout southern Ontario, most are from a few small and significant Carolinian sites.

Introduction

Vickery and Kevan's (1986) monographic treatment of the orthopteroid insects of Canada is the only species-level treatment of an entire major order for the country, providing an essential identification guide and a benchmark against which later distributional records can be assessed. We summarize the significant new Canadian orthopteroid records that have accumulated in the University of Guelph Insect Collection during the almost two decades since the publication of Vickery and Kevan (1986). We also provide further records for species previously unknown in Ontario but recorded elsewhere in Canada, and for species previously known only from one or two locations in Canada. Most of our new records are from ongoing arthropod surveys at several important Carolinian sites throughout southwestern Ontario. All the specimens examined are deposited at the University of Guelph Insect Collection, but some records are from the Royal Ontario Museum as indicated (ROM).

Part one: Orthoptera not previously recorded from Canada:

Acrididae

Melanoplus scudderi scudderi (Uhler) is known from throughout the eastern U.S., but had not been previously recorded from Canada. We found this to be a common species late in the season on low shrubbery in Ojibway Prairie Nature Reserve (Essex County). It also occurs in oak-savannah habitat in Lambton County.

Label data: Ontario: Essex Co.: Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, sweeps, 22 September 2001, S.A. Marshall; Windsor, Ojibway Prairie, 12 May 1999, S.A. Marshall; Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, 16 October 2003, S.A. Marshall; Windsor, Ojibway Prairie, sweeps, 13 August 2001, S.M. Paiero; Windsor, Ojibway Prairie, 42°15'46"N 83°4'2"W, unburnt prairie, yellow pans, 11-14 September 2001, S.M. Paiero; Windsor, Ojibway Prairie, unburnt prairie, yellow pans, 2-5 October 2001, S.M. Paiero; Windsor, Ojibway Prairie, 42°15'42"N 83°4'9"W, burnt savannah, yellow pans, 14-18 September 2001, S.M. Paiero; Windsor, Ojibway Prairie, 42°15'46"N 83°4'17"W, burnt prairie, yellow pans, 9-12 October 2001, S.M. Paiero; Windsor, Ojibway Prairie, 42°15'46"N 83°4'17"W, burnt prairie, yellow pans, 28 September-2 October 2001, S.M. Paiero; **Lambton Co.:** Port Franks, Richmond subdivision, 30 August 1996, K.H. Stead; Port Franks, Karner Blue Sanctuary, 43°13'N 81°54'W, pan traps, 18-25 July 1996, J. Skevington; Port Franks, Watson Property nr. L-Lake, 43°13'N 81°54'W, malaise trap, 7-14 August 1996, J. Skevington.

Melanoplus walshii (Scudder) was previously known from Minnesota, South Dakota and Michigan south to Georgia, but not from Ontario, Michigan's Upper Peninsula, New York or other areas bordering eastern Canada.
Label data: Ontario: Essex Co.: Windsor, Ojibway Prairie, 42°15'46"N 83°4'17"W, burnt prairie, yellow pans, 10-14 August 2001, S.M. Paiero; **Hald.-Norfolk Co.:** St. Williams Nursery, 26 August 2000, M. Gartshore; **Lambton Co.:** Port Franks, Karner Blue Sanctuary, 43°13'N 81°54'W, 22 September 2002, S.A. Marshall; Port Franks, Karner Blue Sanctuary, pan traps, 8-10 July 1996, J. Skevington; Port Franks, Karner Blue Sanctuary, 29 August-3 September 1996, J. Skevington; Port Franks, Karner Blue Sanctuary, pan traps, 8-15 August 1996, J. Skevington; Port Franks, Karner Blue Sanctuary, pan traps, 8-10 July 1996, J. Skevington.

Dichromorpha viridis (Scudder) occurs from South Dakota to southern New England and south to Mexico, but had not been recorded in Canada or close to the Canadian border.
Label data: Ontario: Essex Co.: Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, 20 September 1997, S.A. Marshall; Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, 22 September 2001, S.A. Marshall; Pelee I., Stone Rd. Alvar, 41°47'N 82°40'W, 1 October 2000, S.A. Marshall; Pelee I., old farm, 1 October 2000, S.A. Marshall.

Ellipes gurneyi Günther is a western species known from a few eastern localities in Pennsylvania and Michigan (Bland 2003). We here record it from Port Rowan and Long Point.
Label Data: Ontario: Hald.-Norfolk Reg.: Port Rowan, 2 Jun 1940, F.A. Urquhart (ROM); Long Point, 5 Sep 1987, J. Troubridge.

Gryllidae
Neoxabea bipunctata (DeGeer), the Two-spotted Tree Cricket, is a distinctively coloured species that occurs throughout most of the eastern USA south to Mexico. We here record it from the Ojibway Prairie Nature Reserve, where we have observed this species annually since 1999, and from specimens collected in the 1970s in the Harrow area. The latter specimens were apparently overlooked by Vickery and Kevan (1986).

Label data: Ontario: Essex Co.: Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, 12 September 1999, S.A. Marshall; Windsor, Ojibway Prairie, 13 August 2002, S.A. Marshall; Harrow, 42°2'N 82°55'W, 20 August 1976, C.D. Neilsen; Harrow, 26 August 1974, W.M. Elliot; Harrow, 6 August 1976, C.D. Neilsen.

Oecanthus latipennis Riley occurs from Illinois and Connecticut south to Florida and Arizona, so it is not surprising to find it in Ontario. It has probably been overlooked because of its predominantly arboreal habits.
Label data: Ontario: Essex Co.: Pelee I., Stone Rd. Alvar, 41°47'N 82°40'W, 1 October 2000, S.A. Marshall; **Kent Co.:** Clear Creek, 10 August 2000, S.A. Marshall (photographs only).

Oecanthus laricis T.J. Walker is a rarely collected species previously known only from Ohio and Michigan. We here record it from larch (*Larix laricina*) trees in a small Carolinian fen in Ontario.
Label data: Ontario: Halton Reg.: Milton, Derry Rd. & 4th Line, 43°31'31"N 79°50'25"W, at light, 23 August 2002, S.M. Paiero; **Wellington Co.:** Creiff, 2km SE on 7th Concession, 43°24'57"N 80°7'18"W, fen, on larch; 30 August 2002, S.A. Marshall.

Oecanthus exclamationis Davis occurs from Illinois and Connecticut south to Arizona and Florida, and was previously known from Michigan near the Ontario border. It was not surprising to find this species in Ontario.
Label data: Ontario: Essex Co.: Point Pelee Natl. Pk., Tilden's Woods Trail, 21 September 2000, O. Lonsdale; Pelee I., 30 September 2000, M. Cripps.

Tettigoniidae
Meconema thalassinum (DeGeer) is an introduced species initially recorded in North America from New York (Gurney 1960) and now known from Rhode Island (Hoebeke 1981) and Michigan (Bland 2003). This species, and the subfamily Meconematinae, are newly recorded from Canada. We record it here from Harrow.
Label Data: Ontario: Essex Co.: Harrow, hand collected, 11 Aug 1997, M. Beaudoin.

Neoconocephalus triops (Linnaeus) occurs in the southern United States and the Caribbean, and undoubtedly represent adventitious specimens. Vickery and Kevan (1986) record this species as adventitious but do not indicate where in Canada, if at all, it was recorded.
Label data: Ontario: Wellington Co.: Galt, 20 February 1956, D.H. Pengelly. Toronto, University Ave., 29 March 1933, S.L. Thompson (ROM); Ottawa, 15 February 1923, in bananas, L.E. Johnson (ROM)

Part two: Orthoptera not previously recorded from Ontario:

Gryllidae
Oecanthus argentinus Saussure occurs across the continent from British Columbia to Connecticut, but it has not been recorded from eastern Canada. Vickery and Kevan (1986) suggest that this species "will be able to move northward only to a limited extent" and state that the "prevalence of frosty periods in late September in Ontario would not allow late-maturing individuals to reproduce". They do, however, note that some northwestern populations cope

with the relatively short seasons by producing only a single annual generation. Ontario populations are probably also univoltine.
Label data: Ontario: Middlesex Co.: Komoka Feed Mill Prairie, yellow pans, 42°58'N 81°25'W, 13-30 August 2001, S.M. Paiero.

Part three: Orthoptera previously known only from one or two Canadian records:

Acrididae
Melanoplus differentialis differentialis (Thomas) (the Differential Grasshopper), unlike the other species discussed here, is a pest species that has probably been moving its range northward for several years (Cantrall 1968). Vickery and Kevan (1986) record it from "extreme southwestern Ontario" where it has long been established at Point Pelee. We find this large, distinctively marked species to be very common at a number of sites in Essex and Kent Counties, and record it as far north as Wellington County.
Label data: Ontario: Essex Co.: Harrow, 42°2'N 82°55'W, 12 August 1962, R.S.; Harrow, 42°2'N 82°55'W, August 1961, R.S. Dickhout; Harrow, 42°2'N 82°55'W, July 1961, R.S. Dickhout; Harrow, SE of, 42°2'N 82°55'W, Oxley Poison Sumac swamp, 4 September 1993, B. Larson; Kingsville, 42°2'15"N 82°44'20"W, hand collection, 18 September 1997, J. Sabara; Kingsville, 42°2'15"N 82°44'20"W, in tall grass, 6 September 1987, K. Petrik; Point Pelee Natl. Pk., 12 October 1997, S.A. Marshall; Point Pelee Natl. Pk., SW shore, 2 September 1998, S.A. Marshall; Staples, 42°10'N 82°36'W, 19 August 1983, Logan & Grigsby; Windsor, 42°18'N 83°1'W, 23 August 1983, Logan & Grigsby; Windsor, 42°18'N 83°1'W, 20 August 1981, E. Zaborski; Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, sweeps, 20 August 2001, S.A. Marshall; Woodsley, hand collection, 28 August 1997, Y. Hoang; **Kent Co.:** Clear Creek Reserve, 42°27'58"N 81°43'5"W, 10 October 2003, S.A. Marshall; Rondeau Prov. Pk., South Point Trail, nr. east parking lot, oak savannah, 42°15'42"N 81°50'49"W, malaise, 7 September-7 October 2003, Marshall *et al.*; Rondeau Prov. Pk., South Point Trail, nr. east parking lot, oak savannah, 42°15'42"N 81°50'49"W, 10 October 2003, S.A. Marshall; Rondeau Prov. Pk., South Point Trail, nr. east parking lot, oak savannah, 42°15'42"N 81°50'49"W, malaise, 14 August-7 September 2003, Buck & Marshall; Wheatley, Wheatley campground, 42°6'N 82°27'W, veg. sweep, 19 September 1993, W. Bennett; Wheatley, 42°6'N 82°27'W, 18 August 1959, R.J. Pilfrey; **Waterloo Reg.:** Hespeler, 43°26'N 80°19'W, 13 September 1959, D.H. Pengelly.

Tettigoniidae
Microcentrum rhombifolium (Saussure) was previously known from only one site in Canada (Point Pelee), although it has also been recorded as an adventive species in British Columbia. We here record it from Harrow and Windsor.
Label data: Ontario: Essex Co.: Windsor, 42°18'N 83°1'W, hand collection, 21 September 1997, B. Sabara; NE of Harrow, 42°2'N 82°55'W, 5 September 1992, W B. Larson; Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, 20 August 2001, S.A. Marshall.

Atlanticus monticola Davis was previously known in Canada only from Turkey Point, Ontario. We here report it only from nearby sites in Haldimand-Norfolk County. Ontario's other *Atlanticus* species, *A. testaceus* (Scudder) remains known only from one record at Arner, Ontario (Walker 1905).

Label data: Ontario: Hald.-Norfolk Co.: Manestar Tract, 1 October 1994, D. Sutherland; St. Williams, 15 July 2001, A. & D. Timpf; Manestar Tract, road along north boundary, 29 August 2000, S.A. Marshall (photographs only, males and females).

Gryllidae

Anaxipha exigua (Say) (Say's Bush Cricket) is an uncommon species described by Vickery and Kevan (1986) as occurring in wet areas and near water. The only previous Canadian record of this species was Point Pelee, but we find it to be abundant on the foliage of small shrubs at a number of tallgrass prairie and oak savannah sites.

Label data: Ontario: Essex Co: Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, 12 September 1999, S.A. Marshall; Windsor, Ojibway Prairie, sweeps, 22 September 2001, S.A. Marshall; Windsor, Ojibway Prairie, 26-27 August 2002, S.M. Paiero; Windsor, Ojibway Prairie, 13 August 2002, S.A. Marshall; Windsor, Ojibway Prairie, nr. Sprucewood Ave. obs. point, yellow pans, 26-27 August 2002, Buck & Paiero; Windsor, Ojibway Prairie, nr. Sprucewood Ave. obs. point, yellow pans, 12-13 September 2002, Buck & Paiero; Windsor, ~1.5km S Ojibway Prairie, forest-prairie edge, Malaise, 42°13'34"N 83°4'27"W, 19-31 August 2001, S.M. Paiero; Windsor, 42°18'N 83°1'W, 11 August 1976, S.A. Marshall; Woodsley, 22 August 1976, J.M. Heraty; Point Pelee Natl. Pk., SW shore, 41°47'N 82°40'W, 2 September 1998, S.A. Marshall; **Hald.-Norfolk Co.:** St. Williams Nursery, 13 September 2001, L. Rodger.

Oecanthus niveus (DeGeer) occurs throughout the eastern United States, but it was previously known only from a single Ontario site (Niagara region). We here record it throughout southern Ontario.

Label data: Ontario: Essex Co.: Pelee I., Porchuk property, Malaise, 10-27 September 2002, Porchuk & Marshall; Pelee I., Porchuk property, Malaise, 28 August-10 September 2002, Porchuk & Marshall; Windsor, Ojibway Prairie, 42°15'51"N 83°4'30"W, 12 September 1999, S.A. Marshall; Windsor ~1.5km S Ojibway Prairie, 42°13'34"N 83°4'27"W, forest-prairie edge, Malaise, 22 September-13 October 2001, S.M. Paiero; Pelee I., old farm, 1 October 2000, S.A. Marshall; "Essex Co.", 26 August 1937, W.R. Code; **Kent Co.:** Wheatley, Wheatley Prov. Park, 42°6'N 82°27'W, deciduous forest, 19 September 1993, C.S. Blainey; Kent Co. Forest at Hwy 401, 12 October 1997, S.A. Marshall; **Hald.-Norfolk Reg.:** Hagersville, 52°58'N 80°3'W, 2 October 1983, W A. Harris; **Halton Reg.:** Speyside, on Pine trunk, 4 October 2002, S.A. Marshall; **Lincoln Co.:** Vineland Station, 43°9'N 79°24'W, 26 August 1936; Jordan , 14 September 1915, W.A. Ross; Jordan, 24 August 1922, W.A. Ross; **Welland Co.:** St. Davids, 3 August 1931, W.L. Putman; Fonthill, 43°2'N 79°17'W, 8 September 1984, M.D. Forward; **Wellington Co.:** Guelph, 43°33'N 80°15'W, forest edge, 19 August 1987, T.A. Wheeler; Guelph, 43°33'N 80°15'W, 14 October 1914, (collector not indicated); Guelph, 24 August 1983, N.R. Ennis; Guelph, 7 October 1963, J.D. Van Loon; Guelph, 24 July 1974, G.J. Umphrey; Creiff, 2km SE on 7th Concession 43°24'57"N 80°7'18"W, fen, 3 September 2002, S.A. Marshall; Fergus, on *Pinus* with aphids, 7 Oct 2003, S.A. Marshall.

Oecanthus pini Beutenmüller is a rarely collected species in Ontario, previously recorded only from Essex and Kent Counties. We here record it from Haldimand-Norfolk and Halton Regions.

Label data: Ontario: Hald.-Norfolk Reg.: Manester Tract, 6km NNW St. Williams, 42°42'17"N 80°27'38"W, 24 August 2001, S.A. Marshall; **Halton Reg.:** Speyside, on Pine trunk, 4 October 2003, S.A. Marshall.

Discussion

Most of the new records included here have resulted from new arthropod survey and inventory projects along Ontario's southern fringe, almost entirely in the same protected sites that have recently yielded numerous new records in other taxa (Sugar *et al.* 1998; Bouchard *et al.* 2001; McCorquodale 2001; Skevington *et al.* 2001; Buck 2004; Paiero *et al.* 2004). Some of the newly recorded species are relatively common in southern Ontario and have simply been overlooked, while others are widespread just south of Canadian border and were expected to occur in extreme southern Ontario. *Neoxabea bipunctata*, *Dichromorpha viridis*, and *Microcentrum rhombifolium*, for example, are colourful, easily identified species that occur in a variety of habitats in the United States but appear to be restricted to one or two sites in Canada. More importantly, a significant proportion of the newly recorded species are relatively rare in Ontario and have been overlooked in the past due to their limited ranges and narrow habitat requirements. *Melanoplus scudderi* and *M. walshii*, for example, are brachypterous grasshoppers that occur in highly localized populations in two or three tallgrass prairie or oak savannah reserves. These species, like *Neoxabea bipunctata*, *Dichromorpha viridis* and *Anaxipha exigua*, are provincially or nationally rare species with easily recognizable and easily monitored populations. Other newly recorded species, such as *Oecanthus laricis*, might be genuinely rare, or might only appear rare because they are difficult to collect. Both *Oecanthus laricis* and the similar *O. pini* have been recognized as species of special conservation concern in other jurisdictions (Dunn 2002).

The species treated above represent a large proportion of Ontario's rare Orthoptera, and include many distinctive and relatively easily identified grasshoppers and crickets of potential conservation concern. We hope that the data presented here will encourage further consideration of putatively rare Orthoptera both as indicators of threatened habitat and as threatened species in their own right.

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MANAGEMENT OF RESISTANCE TO INSECTICIDES IN THE OBLIQUEBANDED LEAFROLLER, *CHORISTONEURA ROSACEANA* (HARRIS), (LEPIDOPTERA: TORTRICIDAE) IN ONTARIO ORCHARDS

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We assessed the potential for the management of resistance to organophosphorus (OP) and pyrethroid insecticides in three field populations of the obliquebanded leafroller , *Choristoneura rosaceana* (Harris) (Lepidoptera:Tortricidae), under two control programs. We compared resistance in a grower-devised pest management program and in a more extensively modified program. The former program was a grower selected or devised program that removed all OP and carbamate applications against OBLR, but used OP and pyrethroid insecticides against the other apple pests. The latter program largely substituted *Bacillus thuringiensis* Berliner-derived preparations or spinosad for azinphosmethyl (an OP) against resistant OBLR populations and minimized applications of OP and carbamates, using pyrethroids preferentially against the other apple pests. Generally, resistance declined or did not increase when selection was reduced, i.e., OP insecticides were not used for leafroller control but the decline was faster under programs that avoided the use of OPs, carbamates or pyrethroids. Resistance was lost from some populations in 2-3 generations, similar to declines observed in laboratory studies. Results also indicate that pesticide applications for other pests in the apple system are important in the selection or maintenance of resistance in leafroller populations.

Introduction

Populations of the obliquebanded leafroller, *Choristoneura rosaceana* (Harris) (Lepidoptera: Tortricidae)(OBLR) resistant to the organophosphorus (OP) insecticide azinphosmethyl have been identified from all of the major apple production areas of Ontario. (Pree *et al.* 2001). Cross resistance to phosmet and carbaryl (a carbamate) and increased tolerance to pyrethroids and methomyl were also reported (Pree *et al.* 2001). The data also indicated that resistance was unstable, i.e., partially resistant or mixed populations tended to revert quickly towards susceptibility in the laboratory. Reported here are results of studies to assess the stability and reversion of resistance in field populations at three separate sites. Two programs were assessed: a grower-selected or -devised program that removed all OP and carbamate applications against

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OBLR, but used OP and pyrethroid insecticides against other apple pests (Table 1). The second was a more extensive insecticide resistance management program (IRM) that generally substituted *Bacillus thuringiensis* Berliner (Bt) preparations or spinosad for azinphosmethyl against OP resistant populations for OBLR and minimized applications of OP and carbamates using pyrethroids preferentially against other apple pests. This second program was designed to avoid selection of OP or pyrethroid resistance in OBLR populations that might occur when these pesticides were applied to the system for control of other insects. We anticipated that OP, carbamate, and pyrethroid resistance in OBLR would decrease more quickly in those plots where OP, carbamate and pyrethroid applications would be minimized.

Materials and Methods

Establishment of field plots and protocols for treatments

To assess the potential for management of resistance in OBLR to OP insecticides, two plots (1.8-6 ha) were established in spring 2000 at each of three Ontario apple orchards (Grimsby in the Niagara production area, and Brighton and Grafton in Northumberland) with one of the plots receiving the grower-devised program.

At Grimsby (43°11'N, 79°33'W), the plots were cv Red Delicious. The grower-devised program was applied to1.8 ha consisting of 24 rows of 53 2.2m tall trees spaced 4.8 x 3m. The plot was bordered on the north by tart cherries, by additional apple plantings on the east and west, and by pastureland on the south. The IRM program was applied to 5.7 ha, consisting of 51 rows of 125 trees 2.2m tall spaced 3 x 4.8m. Data were from 27 rows of Red Delicious: other rows of cv. McIntosh and Empire were not sampled. Plots were separated by about 500m, largely planted to tart cherries. The IRM plot was adjacent to additional apple plantings on the north and west sides, which were treated with grower-devised programs. Both plots were sprayed by the grower with a Turbomist sprayer calibrated to deliver 760 L/ha.

At Brighton (44° N 1'N, 77° 43'W), the plots were McIntosh. The grower-devised program was applied to 3.6 ha consisting of 30 rows of 25 3m tall trees spaced 5.5 x 2.4m (this plot comprised about half of a ca. 6 ha planting of McIntosh with 5 rows of Empire in the centre). The plot was bordered by woods on the north and west, by a grassed field on the east and by an additional grower-sprayed orchard on the south. The IRM program was applied to 6 ha of which we used ca 3.8 ha consisting of 13 rows of 45 3m tall McIntosh trees spaced 6.1 x 2.4m, with the rest of the plot planted to cv Paulared and McIntosh. The plot was ca 500m north of the woods and was largely surrounded by wood lots. Both plots were sprayed with an FMC NW 430 sprayer at 660 L/ha.

At Grafton (44° 0'N, 77° 57'W) plots were cv Idared. The grower-devised program was applied to 2.7 ha consisting of 46 rows of 64 2.8m trees spaced 4.3 x 2.1m in of which we used 1.2 ha planted to Idared. The rest of the plot was planted to McIntosh with four rows of cv Cortland adjacent to the Idared planted portion. This plot was bordered by a highway with additional apple plantings on the north and by grassed fields on the other three sides. The IRM program was applied to 2.1 ha which was part of a larger planting of ca. 6.5 ha of cv. McIntosh, Cortland and Idared. The 2.1 ha plot consisted of 21 rows of 64 3.2m trees spaced 5.5x 2.8m. This plot was 750m northeast bordering the additional apple plantings, and was located in the northeast quadrant of the 6.5 ha and bordered the rest of the planting on the west and south sides. The north and east sides were adjacent to pasture. The grower applied his own preferred program to the rest of the planting. Both plots were sprayed with an FMC 250 sprayer at 440 L/ha.

TABLE I. Insect control programs applied by growers 2000-2002.

	OBLR		STLM	CM	OFM	MB	APHIDS/LH	PC	AM/CM	THINNING
	Spring	Summer								
Grimsby - Grower -devised - Red Delicious										
2000	cypermethrin	-	-	-	phosmet	diazinon		-	-	-
2001	cypermethrin	-	-	-	phosmet	-		-	-	-
2002	cypermethrin	-	-	-	cypermethrin	-	pirimicarb/diazinon	-	-	-
Grimsby - IRM - Red Delicious										
2000	Bt (3)1	Bt (2)	-	tebufenozide	-	-	pirimicarb	-	-	Accel*
2001	Bt (2)	Bt	-	tebufenozide	-	imidacloprid	-	-	-	hand
2002	Bt	Bt	-		cypermethin(2)		pirimicarb	-	-	-
Brighton - Grower -devised - McIntosh										
2000	Bt	Bt	-	phosmet	-	-	-	phosmet	phosmet	carbaryl
2001	deltamethrin	spinosad	-	phosmet	-	-	-	phosmet	phosmet	carbaryl
2002	deltamethrin	Bt/spinosad	-	-	-	-	-	phosmet	phosmet	carbaryl/ NAA[2]
Brighton - IRM - McIntosh										
2000	Bt	Bt	-	tebufenozide	-	-	imidacloprid (border)	phosmet (border)	phosmet	hand
2001	Bt	spinosad	-	tebufenozide	-	-	imidacloprid	phosmet (border)	phosmet (border)	hand
2002	Bt	spinosad	-	-	-	-	-	-	phosmet (border)2	hand
Grafton-Grower -devised-Ida Red										
2000	deltamethrin/Bt	Bt	deltamethrin	phosalone(2) phosmet(2)	-	-	-	azinphosmethyl	phosmet(3)	carbaryl
2001	Bt	spinosad	deltamethrin	phosmet2)	-	-	imidacloprid (border)	azinphosmethyl	phosmet	carbaryl
2002	deltamethrin	Bt	-	tebufenozide	-	diazinon	phosalone(2)	-	phosmet(3)	carbaryl

TABLE I. Continued

	OBLR		STLM	CM	OFM	MB	APHIDS/LH	PC	AM/CM	THINNING
	Spring	Summer								
Grafton - IRM - Ida Red										
2000	Bt	Bt	deltamethrin	tebufenozide	-	imidacloprid	-	azinphosmethyl (border)	phosmet (border) 3	carbaryl
2001	Bt	spinosad	-	phosmet (border) 3	-	imidacloprid	-	azinphosmethyl (border)	phosmet (border)2	NAA
2002	spinosad	-	-	phosalone(border)	-	imidacloprid	-	phosalone (border)	phosalone (border)1 phosalone (border)3	NAA

1. Numbers in brackets indicate numbers of repeated applications.
2. NAA, naphthalene acetic acid
OBLR - oblique banded leafroller, *Choristoneura rosaceana* Harris (Lepidoptera: Tortricidae)
STLM - spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabr.) (Lepidoptera: Gracillariidae)
CM - codling moth, *Cydia pomonella* (L.) (Lepidoptera : Tortricidae)
OFM - Oriental fruit moth, *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae)
MB - mullein plant bug, *Campyloma verbasci* (Meyer) (Hemiptera: Miridae)
LH - leaf hoppers, *Typhlocyba pomaria* (McAtee), *Empoasca fabae* (Harris) (Homoptera: Cicadellidae)
PC - plum curculio, *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae)
AM - apple maggot, *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae)

Growers were advised of the occurrence of resistance in OBLR populations at their sites and all elected to use alternative insecticides to azinphosmethyl in their programs. The IRM had a more extensively modified program with no applications of OP, carbamate, or pyrethroid insecticides (Table I). Where alternatives were unavailable or were unacceptable to the grower, border sprays of OP or pyrethroid insecticides (applied to1-2 outside rows) were used as deemed necessary by the grower. Border sprays were not used in the grower-devised plots. Rates used were those recommended in the provincial fruit production guide (Anonymous 2002).

Insecticides for control of overwintered (spring) OBLR were applied about petal fall (early June). For control of the first summer generation of OBLR, (late June-July), sprays were timed according to established degree day models (Solymar 1999) using five pheromone (OBLR lure, Trece, Salinas CA) baited traps (Pherocon II, Trece) at each site to obtain the date of the first sustained moth captures. Traps were separated by at least 30m and examined twice weekly as described in the protocol outlined by Solymar (1999). First applications of insecticides were delayed until 240-260 degree days Celsius (DDC) (base 6.1°C). Applications were repeated if emergence of moths was extended. Insecticides were applied for other pests as identified as necessary by the growers but trap catch data from codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) and apple maggot *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae) traps as well as weekly scouting for the occurrence of mullein plant bugs, Campylomma verbasci (Meyer) (Hemiptera: Miridae), aphids, *Aphis pomi* (DeGeer) and Dysaphis plantaginea (Passerini) (Homoptera:Aphididae) etc. were provided to support spray timing and/or needs for control treatments (Table I). Sampling procedures, traps, appropriate timings, etc., were as outlined by Solymar (1999).

Monitoring of resistance

OBLR larvae (200-400) of the overwintered (spring) generation were collected from each plot at each site in spring of each year of the study (2000-2002) just after bloom and prior to any insecticide treatments, and placed on an artificial diet (Pree *et al.* 2001). Moths developing from these collections were reared and larvae produced from mass crosses were assayed for resistance using a Potter spray tower and analytical grade samples of insecticides dissolved in acetone (Pree *et al.* 2001). Concentrations used as diagnostic were 40 mg/kg for azinphosmethyl and 2.5 mg/kg for cypermethrin (a pyrethroid). At these diagnostic concentrations, all susceptible individuals were killed; the 40 mg/kg concentration of azinphosmethyl killed ca. 15% of a laboratory selected OP-resistant population used as a reference or standard resistant population in earlier studies (Pree *et al.* 2001) and the 2.5 mg/kg solution of cypermethrin killed ca. 50% of a similarly selected pyrethroid-resistant population. For tests, we used 10 replications of 10 larvae at each diagnostic concentration. Tests were conducted on at least two days and larvae were from at least 6 egg masses.

Because the inequality of variances prevented transformation of these data to fit a normal distribution, the percentage of resistant individuals in each plot in each year was compared using the Mann-Whitney rank sum test (Zar 1974) ($P<0.05$, SigmaStat, Version 2, SPSS Inc., Chicago IL). Comparisons were made separately between treatments (grower-devised vs. IRM) and for changes in population responses between years for each treatment.

Efficacy

The effectiveness of the programs in controlling OBLR was determined approximately one week prior to harvest by assessment of fruit for larval feeding damage. Sample trees (5% of the

trees in each plot) were selected randomly, and 50 fruit were examined on each tree. Ladders were used on larger trees and adjacent trees were sampled where less than 50 fruit were available. Percentage fruit damage from each plot at each site was compared with the Mann-Whitney rank sum test (SigmaStat). Overall means for fruit damage at the three sites in the grower-devised and IRM plots were compared using the same test.

Results and Discussion

Insect control programs at the three sites varied widely, with the grower's experience dictating the need for the various insecticides applied for pests other than leafrollers (Table I). The sites at Brighton and Grafton had more insecticides applied than the Grimsby plots. Growers were advised of the presence of OP resistance in OBLR populations in both plots at their sites and all avoided the use of OPs for control of OBLR. Therefore, any differences or reductions in resistance observed between the two programs were likely associated with resistance selection caused by OP (or pyrethroid) use for other pests. The number of treatments of OP insecticides applied for control of other insects or carbaryl (a carbamate insecticide) for thinning (removal of excess small fruit) in mid-late June varied from one-two at Grimsby to four-five at Brighton, and to four-nine at Grafton (Table I).

In 2000 at Grimsby in the grower-devised plot, for OBLR the grower made a single application of cypermethrin (Table I). In the IRM plot, he made three applications of Bt, as Foray 48BA, for control of the spring generation and two more for the first summer generation. The OBLR populations in the grower-devised plot were reduced to levels that prevented further samples in that plot in the subsequent years of the test. There was no significant difference for the OP resistance and the pyrethroid susceptibility between the populations of the two plots in 2000 (Tables II and III). However, the OP resistance significantly decreased from 2000 to 2002 in the IRM plots, and the pyrethroid susceptibility did not change over that same period.

In 2000-2002 at Brighton in the grower-devised plot, for OBLR the grower made a combination of Bt, spinosad and deltamethrin applications (Table I). In the IRM plot, he made applications of Bt and spinosad. There was no significant difference in the OP resistance between the populations in 2000 and 2002, however, in 2001 the OP resistance in the grower-devised plot was significantly greater than in the IRM plot (Table II). OP resistance significantly decreased after two years of treatments in the grower-devised plot from 2000 to 2002, whereas, in the IRM plot OP resistance significantly decreased after one year (Table II). Pyrethroid susceptibility was significantly greater in the grower-devised plots than in the IRM plots in 2000 and 2001, however, in 2002 there were no significant difference between the plots (Table III). Pyrethroid susceptibility significantly increased after two years in the grower-devised plot from 200 to 2002, whereas in the IRM plots there was no change in susceptibility (Table III).

In 2000 at Grafton, the OBLR population (or at least a substantial portion of the population) was exposed to a prebloom pyrethroid treatment applied to control spotted tentiform leafminer (*Phyllonorycter blancardella* F.). Therefore, except at Grafton, estimates of the percentage resistance in populations (Tables II and III) were established early in 2000 prior to any insecticide use. Changes in resistance are measurements of the impact of control programs used in 2000-2002.

In 2000-2002 at Grafton in the grower-devised plot, the grower made a combination of Bt, spinosad and deltamethrin applications (Table I) for OBLR. In the IRM plot, he made applications of Bt and spinosad. There was no significant difference in the OP resistance between the populations

in 2002, however, in 2000 the OP resistance in the IRM plot was significantly greater than in the grower-devised plot and the reverse was true in 2001 (Table II). OP resistance in 2000 was significantly lower than in 2001 and 2002 in the grower-devised plot, whereas in the IRM plot the reverse was true (Table II). Pyrethroid susceptibility was significantly greater in the grower-devised plots than in the IRM plots in 2001 and 2002, however, in 2000 there were no significant difference between the plots (Table III). Pyrethroid susceptibility was variable in the same way in both plots from 2000 to 2002; the OBLR populations were significantly more resistant to pyrethroids in 2001 relative to 2000 and 2002 (Table III). Application of a pyrethroid (cypermethrin) to a similar population at the Grimsby site reduced populations to levels, which prevented further samples for resistance testing. In this case, numbers of OBLR surviving in this plot were high enough to allow collection of a sample adequate (>200 larvae) for tests of resistance frequencies.

At both Grimsby and Brighton, in populations sampled in spring 2000, prior to the establishment of the two programs, the grower-devised and IRM had similar resistance levels (Table II). At both sites, the populations in both plots were largely resistant to OP insecticides (71-87% survival) but were susceptible to pyrethroids (0-19% survival). At Brighton, OP and pyrethroid resistance was not detected after one year (as measured in 2001) in the IRM plot and after two years in the grower-devised program plot (as measured in 2002). Both of these plots were adjacent to large wood lots on at least two sides and migration of susceptible moths from these areas may have influenced the rate of changes in the susceptibility of these populations. OBLR has an extremely wide host range and larvae could develop on many rosaceous or nonrosaceous species (Chapman and Lienk 1971). Both treatment groups at Brighton and the IRM group from Grimsby remained susceptible to pyrethroids (Table III).

At Grafton, OP resistance was initially higher in the IRM plot than in the grower-devised plot (84% vs. 45%). Under the grower's program, OP resistance increased from 45% to 91%, probably associated with the extensive OP program used for other insects. While OP resistance declined somewhat in the IRM plot in the first year of the test (from 84% to 64%), the decline was not continued in the second season. This plot received approximately nine border sprays of OP insecticides in the second season and these may have affected any further decline of this resistance. The percentage of the population exhibiting pyrethroid resistance was unchanged over the two seasons in both plots, even though after one year OBLR populations were more resistant (Table III).

The decrease in damage to apples in Grimsby and Brighton by the OBLR from 2000 to 2002 (Table IV) was parallel to the trend of decreasing resistance of OBLR to both OP and pyrethroids (Tables II and III). However, damage declined in plots with either treatment over the three years of the study. This was probably associated with the large initial variation in infestations between sites in 2000. However, at Grafton in spite of the trend of decreasing damage to apples over the same period (Table IV), there was no similar parallel decrease in OP and pyrethroid resistance (Tables II and III).

Overall, OP resistance declined, or, at least, did not increase in plots with a IRM strategy that avoided the use of OP and pyrethroid insecticides both for OBLR and for other pests. OP resistance also declined at Brighton under the grower-devised program that avoided the use of OP or carbamate insecticides for OBLR control. Resistance was lost more rapidly in the IRM plot at Brighton. It is likely that the extensive use of border sprays of OP insecticides (up to six were applied to the IRM plot) at Grafton delayed or reduced the decline in the numbers of

TABLE II. Management of resistance to organophosphorus insecticides in populations of oblique-banded leafroller 2000-2002.

Population	Program	Percentage Survival at Diagnostic Concentrations Azinphosmethyl 40 ppm		
		2000	2001	2002
Grimsby	Grower	80 a[1]	-	-
	IRM	83 aA[2]	43B	22 C
Brighton	Grower	87 aA	52 aB	0 aC
	IRM	71 aA	0 bB	0 aB
Grafton	Grower	45 aB	88 aA	91 aA
	IRM	84 bA	64 bB	68 aB

[1] Numbers in same column within each site followed by same lower case letter are not significantly different by Mann-Whitney rank sum test P<0.05.
[2] Numbers in same row for within each plot at each site followed by same capital letter are not significantly different by Mann-Whitney rank sum test P<0.05.

TABLE III. Management of resistance to pyrethroid insecticides in populations of oblique-banded leafroller 2000-2002.

Population	Program	Percentage Survival at Diagnostic Concentrations Cypermethrin 25 ppm		
		2000	2001	2002
Grimsby	Grower	7 a[1]	-	-
	IRM	9 aA[2]	3 A	2 A
Brighton	Grower	19 aA	16 aA	0 aB
	IRM	0 bA	0 bA	1 aA
Grafton	Grower	56 aB	84 aA	57 aB
	IRM	41 aB	66 bA	38 bB

[1] Numbers in same column within each site followed by same lower case letter are not significantly different by Mann-Whitney rank sum test P<0.05.
[2] Numbers in same row within each plot followed by same capital letter are not significantly different by Mann-Whitney rank sum test P<0.05.

TABLE IV. Damage to apples by the oblique-banded leafrollers. 2000-2002.

		Percent Apple Damage		
		2000	2001	2002
Grimsby				
	Grower	1.2 ± 1.9[1] a	1.4 ± 2.2 a	0.09 ± 0.4 a
	IRM	14.7 ± 9.6 b	5.5 ± 5.8 b	0.9 ± 1.7 a
Brighton				
	Grower	35.2 ± 22.4 a	4.4 ± 2.2 a	4.0 ± 3.3 a
	IRM	9.8 ± 9.5 b	6.3 ± 4.2 a	8.0 ± 4.4 b
Grafton				
	Grower	4.6 ± 5.0 a	3.1 ± 3.7 a	2.8 ± 2.9 a
	IRM	15.4 ± 8.2 b	2.6 ± 2.4 a	0.9 ± 2.0 b
Mean ± SE				
	Grower	13.7 ± 18.7[2] A	3.0 ± 1.5 B	2.3 ± 2.0 C
	IRM	13.3 ± 3.1 A	4.8 ± 1.9 B	3.3 ± 4.1 C

[1] Numbers in same column for each site followed by same lower case letter are not significantly different by Mann-Whitney rank sum test $P<0.05$, comparisons are within each site.
[2] Numbers in same column for overall mean for each year followed by same capital letter are not significantly different by Mann-Whitney rank sum test $P<0.05$.

resistant larvae in those populations. In laboratory studies, Pree *et al.* (2001) found that resistance declined from 88% to about 12% in the laboratory over three generations when selection was not applied to a newly colonized population. Smirle *et al.* (1998) reported similar declines in resistance in laboratory populations from Quebec. In these field studies, we found similar rapid losses in resistance when selection pressures were removed or minimized. Similar rates of loss were observed with a pyrethroid -selected laboratory colony (Pree, unpublished data).

The data generally indicate that resistance in the OBLR can be managed and that programs which use azinphosmethyl in a rotation with Bt preparations and/or spinosad, compounds that do not exhibit cross resistance to OP or pyrethroids (Pree unpublished, Ahmad *et al.* 2002), may be sustainable. The data also indicate that pesticides applied against pests other than OBLR are important in the selection of OBLR populations for resistance and must be considered as part of any resistance management strategy. However, as the data indicate, resistance management strategies that consider these aspects can be successful and can result in rapid loss of resistance.

A rotational program that incorporates azinphosmethyl is about 50$C/ha/yr cheaper than a program that relies on a rotation of Bt and spinosad. However, a number of the products used as replacements for OP and pyrethroid insecticides (e.g., tebufenozide, imidacloprid etc.) are costly and may make the modified program more expensive overall. The exact cost is likely to be highly variable and dependant upon the pests identified as problems in the various orchards.

However, the value of continued efficacy and potential sustainability of the program to the producer must also be considered. This program may lose some feasibility if the use of

azinphosmethyl is severely reduced or curtailed, but the broad range of compounds involved in the resistance suggests that similar programs with other compounds may be feasible. Carrière *et al.* (1996) have shown a positive correlation between resistance to azinphosmethyl and resistance to cypermethrin in populations from Quebec but our field studies identified two populations (Grimsby and Brighton) that were resistant only to OP insecticides and not to pyrethroids.

However, the population from Grafton was resistant to both groups of insecticides. These observations and those of Ahmad *et al.* (2002) and Pree *et al.* (2002) suggest that resistance in the OBLR, to these different insecticides, is a variable system and that the importance of the various resistance mechanisms may vary with the different types of insecticides used in control programs. Despite the broad-spectrum resistance to many insecticides associated with OP or pyrethroid resistance in the OBLR, a potentially sustainable resistance management strategy involving the rotational use of three groups (Bt, spinosyn, and OP) of insecticides is feasible.

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CONTROL OF THE MULTICOLOURED ASIAN LADY BEETLE, *HARMONIA AXYRIDIS* (PALLAS) (COLEOPTERA:COCCINELLIDAE) ON GRAPES IN ONTARIO

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The multicoloured Asian lady beetle, *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae), has become a pest of grapes, *Vitis vinifera L.* (Rhamnales: Vitaceae), in Ontario because beetles present in harvested grapes produce alkaloids (methoxypyrazines) when stressed or as a pheromone, and these can affect the quality of wines and juices. We have assessed the use of selected insecticides in both laboratory and field to determine the potential for control of this pest. Although, the neonicotinoid acetamiprid was most toxic in the laboratory, malathion or cypermethrin were most effective in the field. Malathion was less persistent than cypermethrin; effects were lost within 7 days whereas cypermethrin residues reduced beetle numbers in plots for at least 7 days.

Introduction

The multicoloured Asian lady beetle , *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae), is common in southern Ontario, and like many other species of lady beetle is normally classed as a valuable beneficial species. Introduced initially into North America from Asia in 1916 and in repeated releases since, it has provided effective biological controls in a number of agricultural ecosystems (pecans, strawberries and roses), and is the most common predator of the Chinese soybean aphid, *Aphis glycines* Matsumura (Homoptera: Aphididae) (cited in Koch 2003).

However, *H. axyridis* has become a pest of fruit crops and grapes in Ontario, because in autumn, beetles aggregate and feed on these crops. Whether the beetles cause the primary damage or feed at sites damaged by other insects or birds is not clear but a recent report (Koch *et al.* 2004) indicates a preference for damaged fruits. However, they have become a serious problem on grapes, *Vitis vinifera L.* (Rhamnales: Vitaceae), because beetles are present in harvested bunches and are crushed with the grapes. *H. axyridis*, and some other species of lady beetle produce methoxypyrazines as both an attractant (pheromone) and as a defense mechanism to protect beetles from predators (Hodek 1973). The quality of wines produced from these infested grapes is seriously affected (Pickering *et al.* 2004) and up to 20% of the wines produced in Ontario in 2001 were tainted (G.M.W, personal communication).

This has created a requirement in some seasons for control of these beetles on grapes grown for both wine and juice in Ontario. As part of an initial response to this problem we have investigated the use of selected insecticides. Most of the literature on the effects of pesticides on *H. axyridis* relates to the impact of insecticides on these insects as a non-target species but there are a number of studies summarized by Koch (2003). Generally, these studies indicated that

adults were less sensitive than larval stages. Further, as a group, pyrethroids were most toxic but there were large differences between the various pyrethroids. Carbaryl was rated as highly toxic to adults but few data on the effects of organophosphorus insecticides were presented in Koch's (2003) review. The neonicotinoid acetamiprid was rated highly toxic to eggs, larvae and adults in laboratory studies by Youn *et al.* (2003). Another neonicotinoid, imidacloprid, was less toxic to late instar larvae and pupae.

We have assessed a number of insecticides in laboratory and field but because *H. axyridis* becomes a pest of grape within a few days of harvest, we restricted compounds tested in the field to malathion, acetamiprid and cypermethrin which are registered for use close to harvest (three-seven days preharvest). Carbaryl is allowed up to five days of harvest in Ontario, but residues detected in wine from such uses preclude its use here.

Methods

Laboratory Bioassays

For assays, we used beetles collected from unsprayed vineyards of cv.Riesling in the Vineland area in October 2003. Beetles were collected in polyethylene vials lined with plant leaves, and were held overnight in a refrigerator at 4°C. Insecticides, (malathion, purity 99%, cypermethrin, 98%, permethrin, 98%, and carbaryl 98%) were analytical grade samples (Chem Services, West Chester PA) and acetamiprid, 99.9% a.i., (Bayer Inc, Etobicoke, ON) were applied to beetles in five mL of analytical grade acetone using a Potter spray tower (12 s spray time followed by five s settling time). Controls were treated with five mL acetone. Beetles were anaesthetized with CO2, 30 s at 30 kPa and placed upright in glass Petri dishes on a Whatman #1 filter paper, five/dish, for treatment. Treated beetles were held in 200 mL glass jars for 24h in a rearing room at 22 ± 2°C, 60%RH with a photoperiod of 16:8 (L:D). Beetles unable to walk after prodding with a fine brush were considered dead. For calculation of concentration/response regressions, six concentrations with ten replicates of five beetles were used. Tests were over several days. Data were subjected to probit analysis (POLO-PC LeOra Software, Berkeley, California). Differences in responses of beetles to the various insecticides were considered different if the 95% confidence limits at the LC50 did not overlap.

To determine whether beetles recovered from treatments of acetamiprid, cypermethrin or malathion, we treated ten replications of five beetles at one of the concentrations used in the calculation of the concentration/response regressions described above and assessed mortality at 24, 48 and 72h post treatment to determine whether mortality changed over time (i.e., whether beetles recovered from treatment or more were affected). Differences in means for the three post treatment times were tested with an analysis of variance.

Field Tests

Tests were conducted in a ca. ten -year-old vineyard of cv. Riesling near Vineland, Ontario, where earlier observations had indicated high numbers of beetles. Plots were located on a south facing edge of the vineyard and clearly held a population of *H.axyridis*. Treatments were replicated four times with plots (five vines/plot) arranged in a randomized complete block design. Insecticides, malathion (Malathion 500EC, United Agri Products, London, ON), cypermethrin, (Cymbush 250EC, Zeneca Agro,Stoney Creek ,ON) and acetamiprid (Assail 70WP, DuPont Canada Inc., Mississauga, ON) were applied 23 October 2003. These insecticides were diluted to a rate comparable to 3000L/ha and sprayed to runoff using a Rittenhouse truck-mounted

sprayer (Rittenhouse Sprayers, St Catharines, ON) equipped with a Spraying Systems handgun fitted with a D-6 orifice plate. Pressure was set at 2000 kPa. Each plot required eight to nine L of spray mix. Plots were sampled one day (24 October) and seven days (30 October, 2003) after treatment when total numbers of beetles in bunches and on leaves were recorded for each plot. Data were transformed (log (x+1)), analyzed by ANOVA, and means separated with a Tukey test (P=0.05) .

Results and Discussion

Laboratory bioassays showed that acetamiprid and cypermethrin were most toxic to beetles (Table I). Another pyrethroid, permethrin was less toxic than cypermethrin but was ca. equitoxic to malathion or carbaryl. Observations reported were 24h post treatment. Beetles treated with acetamiprid were affected (appeared immobilized) at concentrations lower than we used in bioassays but these responded as capable of normal movement when prodded. Observations 24, 48 and 72 hours after treatment indicated increased mortality of beetles treated with acetamiprid (Table II). Earlier reports (Williams and Fickle 2003) with another neonicotinoid, imidacloprid, indicated initial knockdown followed by recovery, but this did not occur with acetamiprid. Mortality associated with treatments of cypermethrin or malathion was unchanged in these later observations.

TABLE I. Toxicity of insecticides to field-collected multicoloured Asian lady beetles in the laboratory.

TREATMENT	SLOPE ± SE	LC50 (95% CL)[a] mg/L	χ^2
Acetamiprid[b]	2.4 ± 0.2	22.2 (17.0 - 27.2)	6.4
Cypermethrin	1.4 ± 0.2	28.1 (14.8 - 41.9)	9.8
Permethrin	2.9 ± 0.2	131.5 (108.4 - 154.6)	5.7
Malathion	4.0 ± 0.3	211.1 (129.0 - 287.3)	58.0
Carbaryl	3.6 ± 0.3	91.5 (76.1 - 106.7)	7.2

[a] Mortality 24h after treatment
[b] n = 350

In the field, one day after treatment, plots treated with cypermethrin and malathion had significantly (P=0.05) fewer beetles than untreated plots or those treated with acetamiprid (Table III). A number of beetles on acetamiprid-treated vines were affected similarly to those in the laboratory but crawled readily when placed on the hands of the observers. In other treated plots most dead beetles were on the ground under vines but a few dead individuals were caught up in the grape bunches. In our survey of the literature, we did not find information on whether or not dead beetles are a potential source of methoxypyrazines, or how long these compounds might persist in dead insects. In samples seven days post treatment, plots treated with cypermethrin had fewer beetles than control plots but there were no differences between insecticide treatments (Table III). Whether the numbers surviving in this plot (mean of seven beetles over five vines) are above a threshold which could result in off flavors in wine produced

TABLE II. Influence of holding time on the toxicity of insecticides to multicoloured Asian lady beetles.

TREATMENT	PERCENT MORTALITY Hours after Treatment[a]		
	24h	48h	72h
Acetamiprid 30 ppm	56b[a]	84[b]	76[b]
Cypermethrin 50	70[a]	82[a]	78[a]
Malathion 200	30[a]	32[a]	34[a]

[a] Beetles held at 24°C, 60% RH

[b] Means of 10 replications of 5 beetles: means separated by ANOVA, numbers in same row followed by same letter NSD

TABLE III. Control of multicoloured Asian lady beetles on Riesling grape - 2003.

TREATMENT[a]	RATE g a.i./ha	BEETLES/PLOT DAYS AFTER TREATMENT	
		1	7
Cypermethrin (Cymbush 250EC)	60	0.0[bb]	7.0[b]
Malathion (Malathion 500E)	900	0.3[b]	11.0[ab]
Acetamiprid (Assail 70WP)	56	11.8[a]	27.0[ab]
Control	-	25.8[a]	38.8[a]

[a] Applied 23 October 2003, plots 7.5 long in 2.1 m spaced rows, replicated 4 times.

[b] Numbers in same column followed by same letter are not significantly different $P<0.05$, Tukey test

from these grapes is not known and may require considerable additional study. In any case, it would be advantageous for dead beetles to fall to the ground so they would not be harvested with the grapes.

The lack of control with acetamiprid was surprising given the results of the laboratory assays: the rate we tested in the field was based on rates recommended (Anonymous 2003) on grape for leafhopper control. Reissig (2003) reported that another neonicotinoid, imidacloprid, which was highly toxic in laboratory tests against apple maggot, (*Rhagoletis pomonella* (Walsh)) (Diptera:Tephritidae), was less effective than expected when applied to foliage in the field. Hu *et al.* (1998) speculated that the ineffectiveness of imidacloprid against apple maggot in the

field might be associated with rapid absorption and consequent inactivity against insects on the surface or to rapid degradation by sunlight.

Cypermethrin-treated plots had fewer beetles (than controls) in samples both one day and seven days post treatment indicating that toxic residues persisted at least seven days. Malathion reduced beetle numbers in samples one day post treatment, but was not effective in the sample seven days post treatment. Currently, cypermethrin has a seven-day preharvest limit on grape (Anonymous 2003) and appears to be the product of choice based on these trials. However, it is not registered for use in the U.S. and would not be useful on grapes grown for juice for export. Malathion was effective in samples one-day post treatment and can be used up to three days preharvest and might be used on grapes grown for export.

This study has identified two insecticides that reduced infestations of *H. axyridis* on grapes, and which may be used close to harvest when beetles become a problem. This may provide an immediate or short-term response to a new problem but in the longer term, management of beetle populations below a still to be determined threshold by other means is desirable. *H. axyridis* is beneficial throughout much of its life cycle, and effective populations should be preserved.

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BOOK REVIEWS

Damselflies of the Northeast. 2004. *by* Ed Lam. Biodiversity Books, Forest Hills, New York. 96 pp. ISBN 0-9754015-0-5. $20 US.

Once in a while a landmark resource guide is produced. Ed Lam has done just that with his excellent new guide to the adult damselflies of northeastern North America. While many guides have been produced recently for Odonata (dragonflies and damselflies), none have managed to take the advances that have occurred within the realm of bird field guides and adapt them to this group of insects – until now! Unfortunately, however, it only covers one half of the order – the Zygoptera or damselflies. This suborder is, however, the one that provides the most grief and frustration for those beginning to learn how to identify Odonata.

The guide itself is relatively small and compact, measuring 5.5 by 8.5 inches, with a total of 96 pages and could, therefore, be easily carried in the field. It covers 69 species and subspecies of damselflies and is fully illustrated with more than 300 detailed paintings, drawings and photographs. The text is well written and the illustrations are nothing short of spectacular! They are so detailed that they have a photographic quality to them.

The guide begins with an introduction to damselflies, followed by a nicely written overview of their life cycle. Next, a richly illustrated, two-page spread covers all of the adult anatomical features, including wing venation, relevant to species identification. A wonderful section entitled "Species Identification" acts as a "how to" for species identification at three levels: in the field, in the hand, and under the microscope. Also included in this section are useful tips on how to catch and collect damselflies. Finally, within the introductory section, two pages provide information on how the species accounts are organized.

The species accounts themselves are well organized and attractively laid out with a full page dedicated to a single species. The illustrations include a dorsal view for males (complete with accurate wing venation – no small task!) and lateral views for both sexes. When necessary, additional lateral views illustrate different colour forms or mature versus immature individuals. Illustrations (some black and white, others in colour) are also provided, when necessary, to illustrate features such as male or female genitalia, or more detailed patterns of the head, thorax or abdomen. Key markings and features are indicated by lines pointing directly to the feature with a short description (e.g., "segments 8-10 completely blue"). Each species account contains a general description of the damselfly (complete with measurement ranges in both inches and millimeters) along with notes on its habitat, distribution and status. At the bottom of each page, a section provides detail on similar species – an indispensable feature for a field guide. Icons for each species (and sex), indicate whether it can usually be identified by binoculars, requires a hand lens, or if it a microscope is needed – this is a unique and useful feature of this guide. A silhouette is also featured providing the actual size of an average specimen. Finally, a range map is provided for each species, indicating known distribution to the county level.

Each of the three families, and most of the genera within the family Coenagrionidae (pond damsels), begin with a page introducing the family or genus and is accompanied by a photograph or two and an excellent overview of the group.

Within the genus *Enallagma* (American bluets), many females can only be reliably identified by examining details of their thorax (mesostigmal laminae) under a microscope or with a powerful hand lens. While many books and guides in the past have chosen to ignore this, Lam rises to the occasion and provides the user with an appendix illustrating these features.

Although this is, in my opinion, the best guide ever produced on the subject, it does have some faults. As far as the production is concerned, some pages are already becoming loose on my copy. Although I find it hard to put the book down, I can't say that it's been extensively used and I fear what effect a few trips in the field will have on it. I'm also disappointed in the coverage depicted in the range maps. Strictly from an Ontario perspective, it's unfortunate that the extreme southwestern tip of the province has been cut off and that more of northern Ontario is not included. From a broader Canadian perspective, the map could have been extended to the east and the north to encompass all of the Maritime Provinces and northern Quebec without having to add any species. A user from Nova Scotia or Newfoundland may not realize, for example, that the guide is actually fully applicable to their area. Along the same lines, the area of coverage could have been extended west to include Michigan, all of Ohio, Indiana, Illinois, Wisconsin and northwestern Ontario with the addition of only two species (*Argia plana* and *Coenagrion angulatum*, the latter of which is the only Ontario species not featured in this guide). I realize that a cut-off has to be made somewhere but I think that the area covered could have been greatly increased with minimal effort.

Users from Ontario also need to be aware that Smoky Rubyspot (*Hetaerina titia*), illustrated on page 22 of the guide, does not have extensively dark wingtips in this part of their range. Rather, the dark tip on the wing is barely discernable. "Our" form is not illustrated nor is it mentioned in the text. In fact, the only mention of variation is that males may be MORE extensively marked in dark brown on the wing than is illustrated. This is unfortunate and will surely confuse many users from this part of their range – possibly leading them to misidentify Smoky Rubyspots as American Rubyspots *Hetaerina americana* (a closely related, but more common species that shares many characteristics).

The above faults are minor in the big picture. As stated earlier, in my opinion this book is the best guide ever produced for Odonata. Ed Lam has raised the bar considerably within the realm of Odonata field guides. This guide deserves a place both on the bookshelf and in the field bag of anyone with an interest in damselflies. Amateur naturalists with an interest in learning the damselflies, who have been either intimidated in the past by the technical nature of scientific treatments or frustrated with the lack of sufficient detail in the available field guides, will find that this is the guide they have been waiting for. Experienced entomologists and odonatologists will also find this book to be a wonderful and informative resource. Now we just need a companion volume for the dragonflies!

Further information on this book, including samples of the illustrations and species accounts, and how to order a copy can be found at: http://homepage.mac.com/edlam/book.html

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Insect and Bird Interactions. 2004. *edited by* Helmut van Emden and Miriam Rothschild. Intercept Publishers, Ltd., Andover, UK. ISBN 1-898298-92-0.70£ or 112 Euros.

I wanted to be an ornithologist by the age of four. Bird-watching controlled my life until 16 years later when a peripheral interest in insects was rekindled, leading to a 30-year career studying bees and butterflies. I enthusiastically agreed to review "Insect and Bird Interactions" (IBI) which the book's cover informs us "...is the first of its kind to explore the diversity of interactions between insects and birds."Given my personal experiences, I had a set of topics I hoped would be explored (including butterflies and bees!). Having birded several spring migration hot-spots, like Point Pelee, I was particularly interested in how hungry birds affect the phenology and abundance of the insects they encounter during the 3-4 weeks of migration. Although I was somewhat disappointed because IBI failed to cover this and most other topics on my mind, as a consequence I learned about many other topics.

Part 1 of the book discusses "population management issues." The first chapter (as well as Chapter 16) demonstrates that in simple environments, we can obtain insights and model populations with a high degree of certainty. However, when that focus is shifted to more complex communities of birds and their prey (Chapter 6), we see that for most birds the real world is too messy to allow modeling in all but the most intensively studied systems.

Chapters 2-4 discuss the depressing effects of modern agriculture on natural biodiversity. The difficulty of precisely determining the insects that comprise the foods of any bird species in a community, coupled with the contributing factors of variable farming techniques and applications of pesticides by growers, make it impossible to directly link changes in bird populations with specific agricultural activities. Nevertheless, numbers of many British birds are declining in part due to new farming practices, especially the loss of buffer zones around fields and the removal of weeds with herbicides. The best data are derived from detailed studies of the Grey Partridge (Chapters 3 & 7). I enjoyed the detailed account of the chough, for which a strong relationship between livestock grazing patterns and crane fly ecology seems to determine the quality of foraging conditions and consequently nesting success for the birds. This is an excellent example of research that provides humans with information we can use to modify farming activities to improve conditions for birds.

Chapters 7-9 concern the effects of insecticides on bird populations. The overall tone is that insecticides are generally bad for birds—a fairly safe assumption that nevertheless demands empirical support. Unfortunately, the authors are forced to rely extensively on logic and "soft" data because the complexity of the systems limits our ability to conduct "hard" tests; consequently, their arguments will fail to convince the skeptics. From an historical analysis, Colin Walker (Chap. 9) suggests that the use of cyclodiene insecticides, not DDT/DDE, were probably responsible for the egg-shell thinning that led to declines of Sparrow hawks and Peregrines in the UK. Unfortunately, American data are only briefly referred to, leaving me uninformed about how the UK experience relates to the generally accepted story that DDT and its metabolite DDE caused declines in raptors in North America.

Part 3 has 8 chapters concerning foraging behaviour of birds. I was impressed with the complex colour vision of birds that includes perception of UV-wavelengths (Chaps. 10 & 11). In addition, the story that I learned long ago, that birds have a poor sense of smell, is shaken by experiments in which birds adjust their feeding in response to various odours (Chap. 12-15).

These chapters force us to rethink warning colouration and mimicry in insects in terms of the visual and olfactory stimuli that specific avian predators can perceive. Also, we cannot assume that one bird perceives an insect in the same way another does, further complicating the study of mimicry. Detailed analysis of the ant prey of wrynecks (Chap. 16) clarifies why this species can survive in both natural and highly managed ecosystems, but fails to provide guidance for us to conserve this uncommon and declining species because "the impact of modern agricultural practices on ant communities is not known."

The last three chapters concern the ectofauna of birds. Chapter 18 reviews the various defenses birds have against ectoparasites. I was disappointed that the authors chose not to discuss the evidence relating to the well-known Hamilton and Zuk handicap principle. On the other hand, the extent to which bill morphology represents a compromise between preening and foraging abilities was particularly interesting. Chapter 19 provides a strong argument that young Common Cuckoos acquire their lice from conspecifics on the wintering grounds. However, it is poor science to use data from obligate brood parasites (cuckoos) to question the vertical transmission of lice from non-parasitic parents to their young.

As is true of many edited volumes that emerge from symposia, the various styles and variable depths of the book's chapters fail to provide a comprehensive overview of the subject. Several chapters could have been replaced. Chapter 1 (shorebird ecology) and Chapter 10 (the avian retina) make no mention of insects. (The relevant information from Chap. 10 is repeated and placed in entomological context in Chap. 11). Chapter 20 was written for phylogenetic specialists and the primary message will escape most readers. Some other chapters are so specific (i.e., individual experiments) that the uninformed reader will have difficulty placing them into context. Many topics and taxa (e.g., bee-eaters, honey-guides) were neglected. Despite these shortcomings, I learned many interesting things from IBI, as highlighted above. It is discouraging that for most bird species, complex diets coupled with species-specific olfactory and visual abilities, temporal changes in insect communities, and complex interactions with numerous other birds and insects, make it impossible to fully understand their effects on individual insect species. With the added unknowns of global warming and a paucity of ornithologists who understand insects (and vice versa), it becomes apparent that this topic will remain blurred for years to come.

Although too complicated for most birders, this book will appeal to both insect and bird behaviourists and ecologists. The early chapters should also be of interest to people interested in the effects of modern agricultural practices on natural communities. However, I am unsure how many of these individuals will find enough of interest to be satisfied. Academic institutions should purchase IBI as a reference work.

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2004 ANNUAL MEETING

The **Entomological Society of Ontario** is grateful for the support received from Entomogen Inc. and Totallybuggy Ltd. for the **141st Annual Meeting** held in St. Catharines ON at Brock University on November 5 to 7, 2004.

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